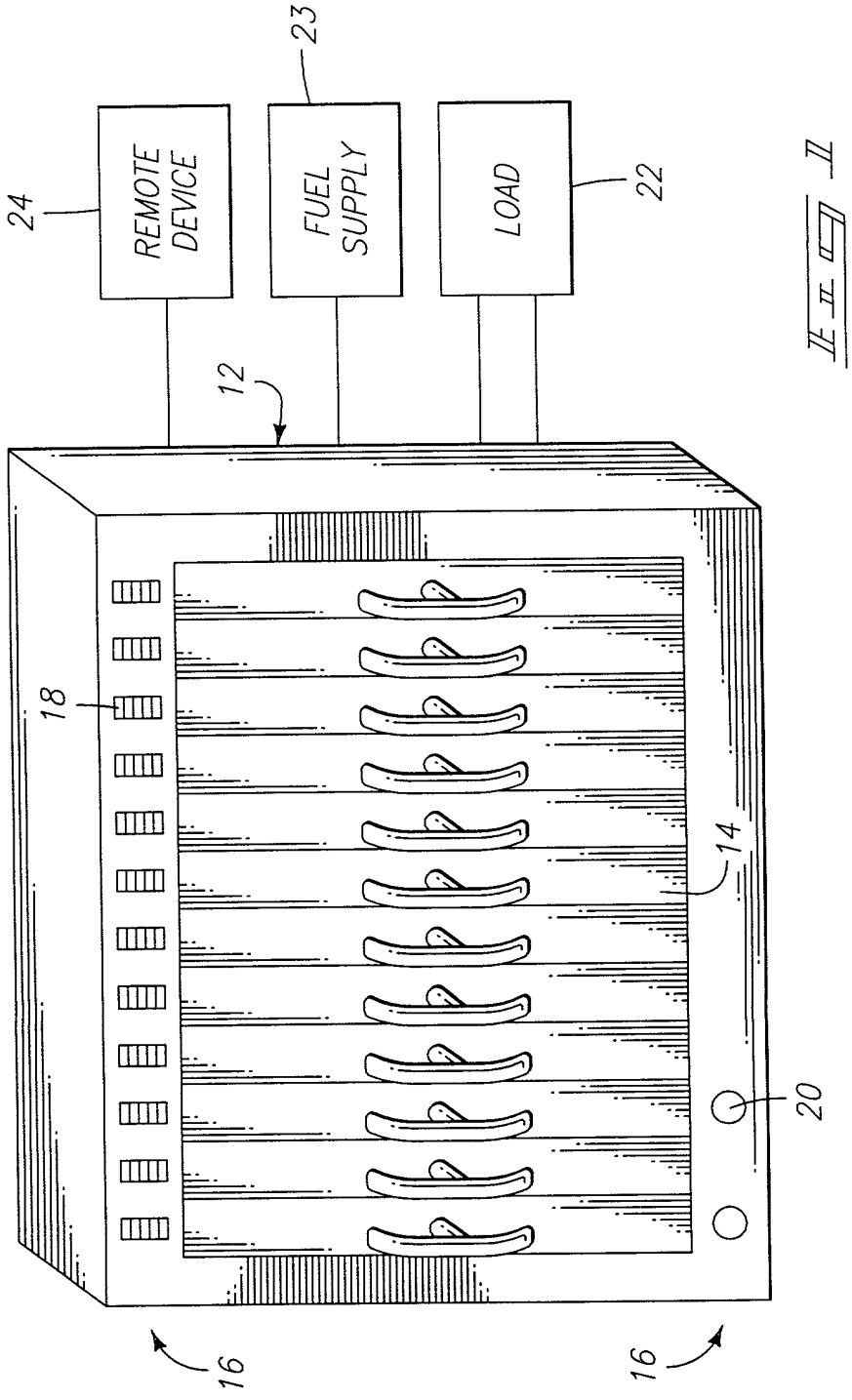

FIG. 1

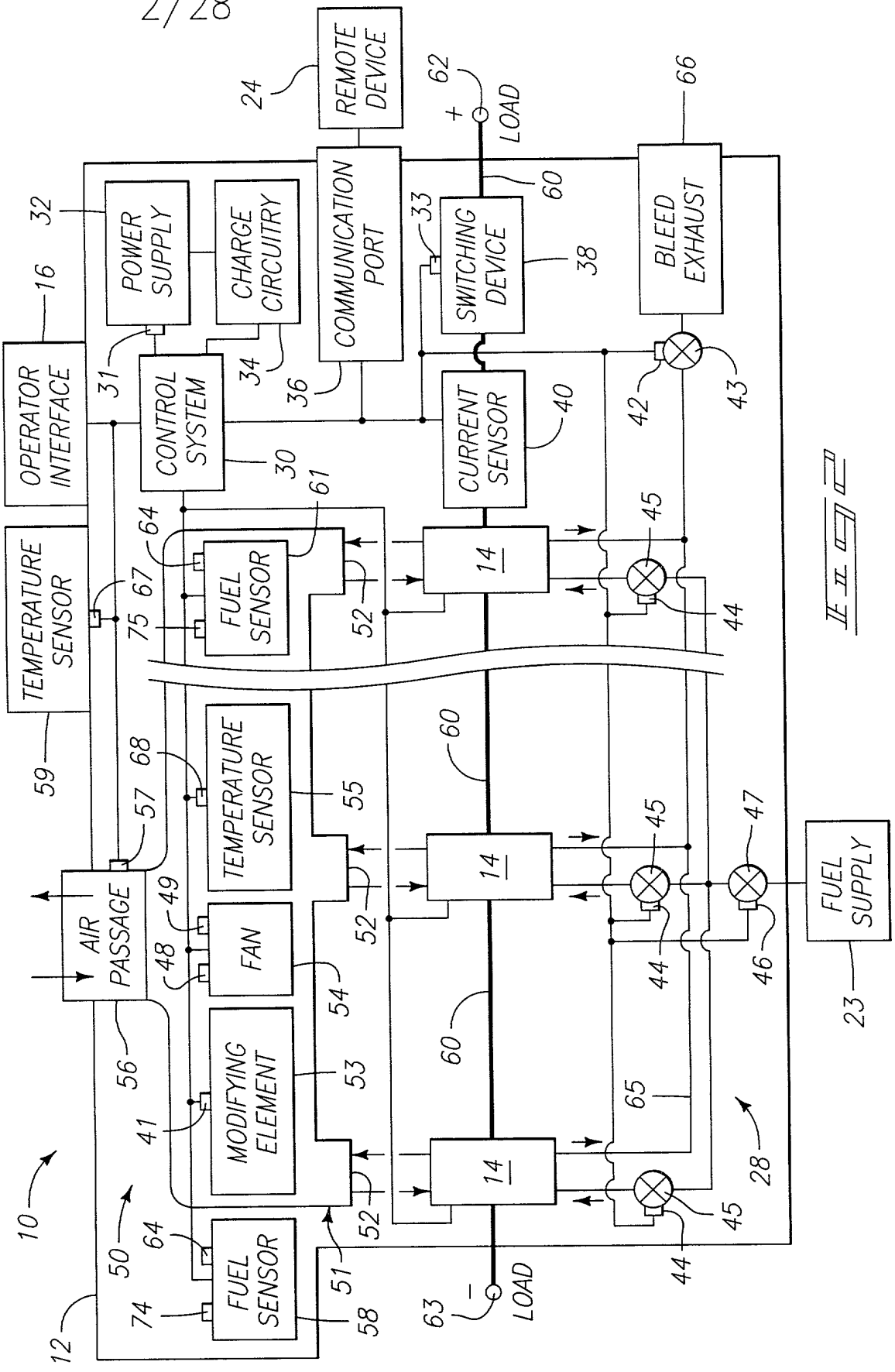
REMOTE DEVICE
24
62
+
LOAD
66
BLEED EXHAUST
32
POWER SUPPLY
CHARGE CIRCUITRY
COMMUNICATION PORT
33
SWITCHING DEVICE
38
60
16
OPERATOR INTERFACE
31
CONTROL SYSTEM
34
36
30
CURRENT SENSOR
40
42
43
61
64
FUEL SENSOR
67
75
TEMPERATURE SENSOR
59
52
14
45
44
68
57
TEMPERATURE SENSOR
55
60
AIR PASSAGE
49
48
FAN
54
56
MODIFYING ELEMENT
53
41
65
47
FUEL SUPPLY
23
46
10
50
64
FUEL SENSOR
74
58
51
12
63
–
LOAD
28

FIG. 2

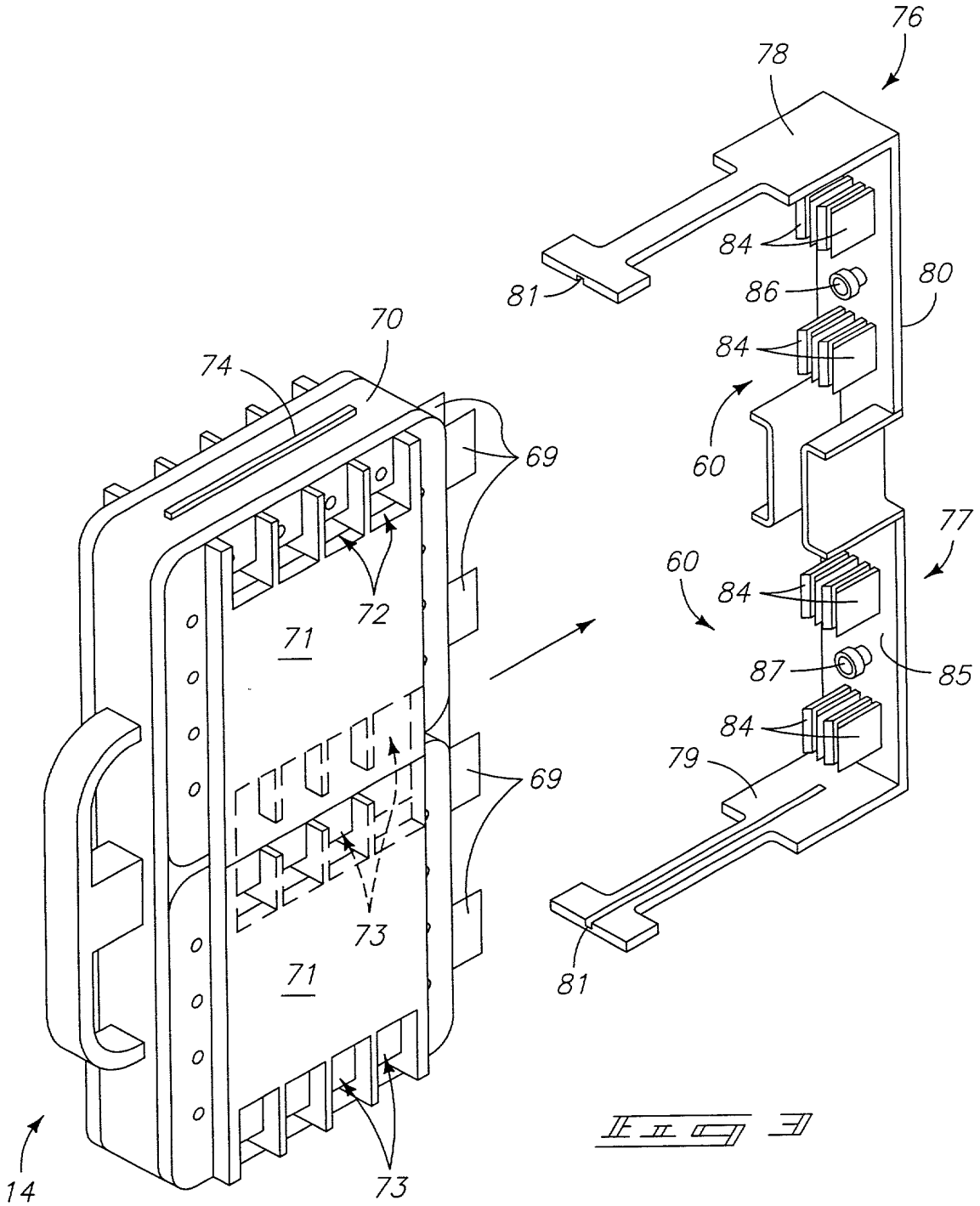
76
78
84
81
86
80
84
70
74
69
60
77
60
84
72
71
87
85
84
79
69
73
71
81
14
73

Fig 3

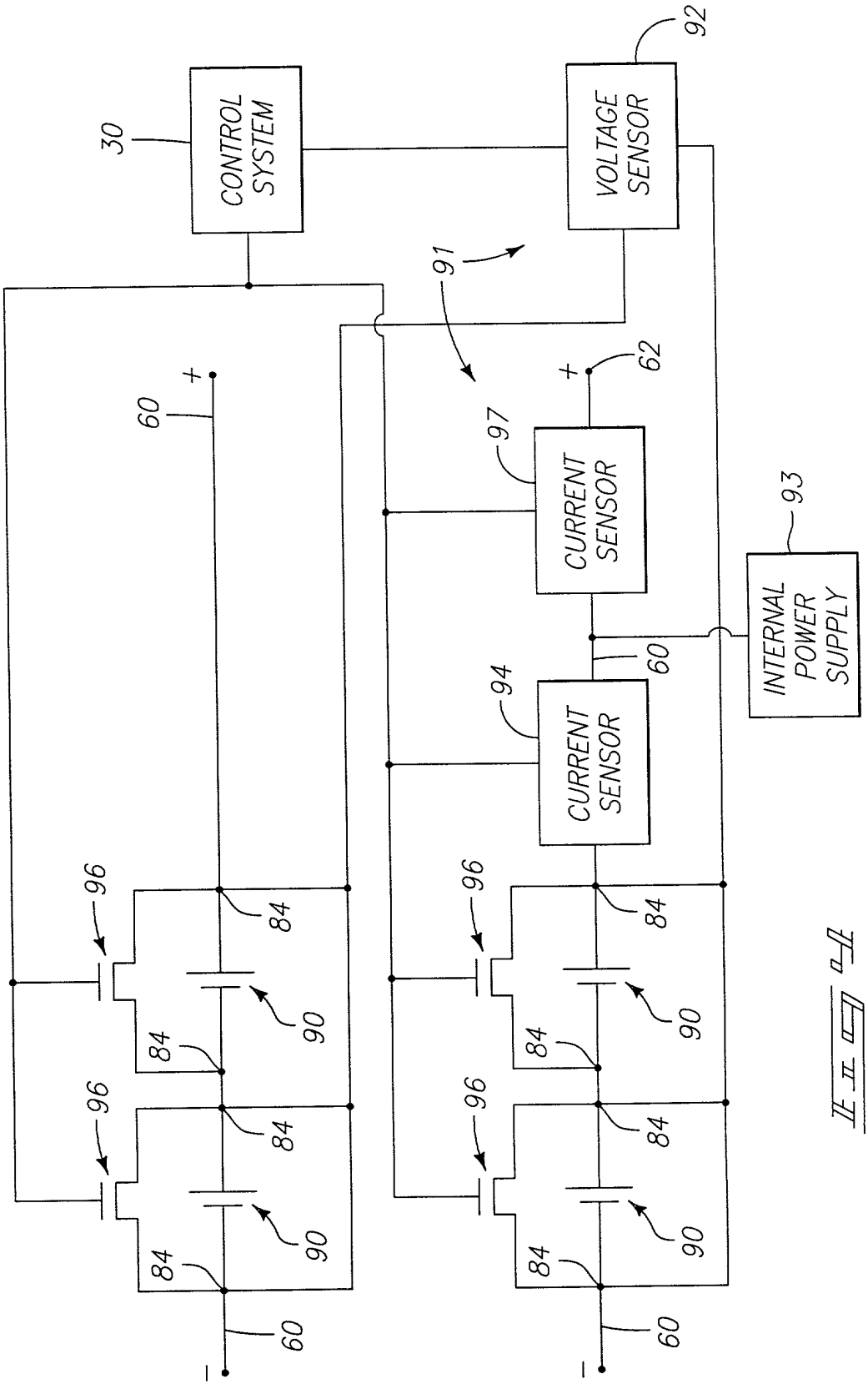
30
CONTROL SYSTEM
92
VOLTAGE SENSOR
91
60
+
62
+
97
CURRENT SENSOR
93
INTERNAL POWER SUPPLY
94
CURRENT SENSOR
60
96
84
90
84
96
84
90
84
96
84
90
84
60
-
60
-

FIG 4

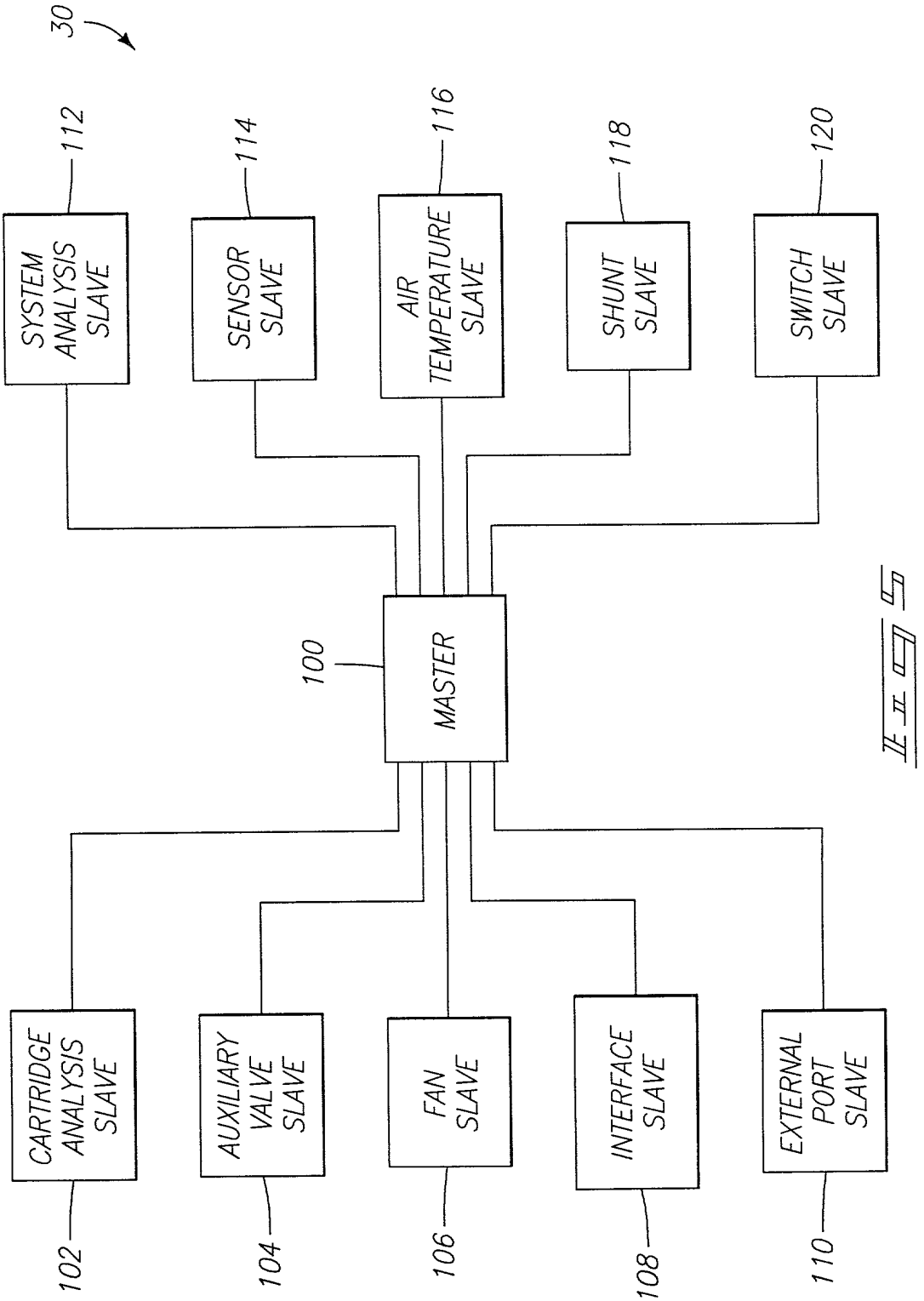
30
112
SYSTEM ANALYSIS SLAVE
114
SENSOR SLAVE
116
AIR TEMPERATURE SLAVE
118
SHUNT SLAVE
120
SWITCH SLAVE
100
MASTER
102
CARTRIDGE ANALYSIS SLAVE
104
AUXILIARY VALVE SLAVE
106
FAN SLAVE
108
INTERFACE SLAVE
110
EXTERNAL PORT SLAVE

Fig. 5

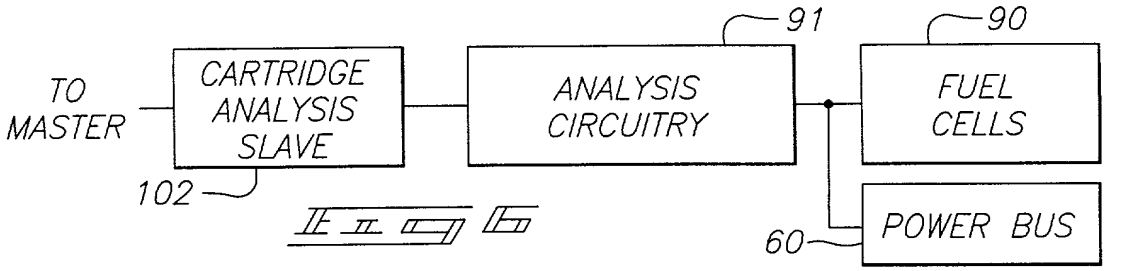

FIG. 6

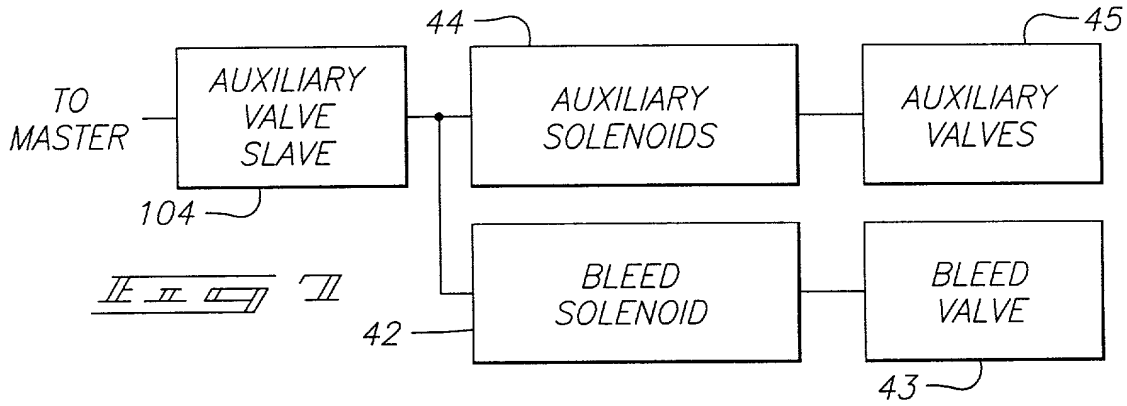

FIG. 7

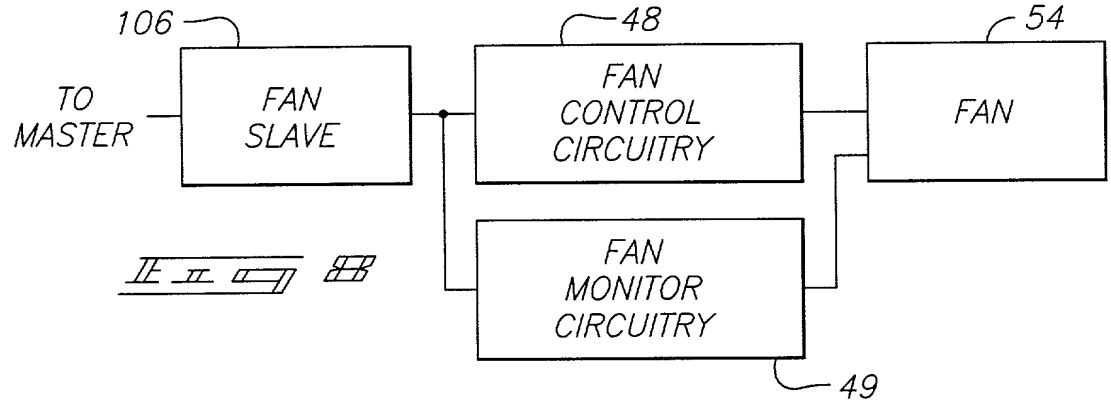

FIG. 8

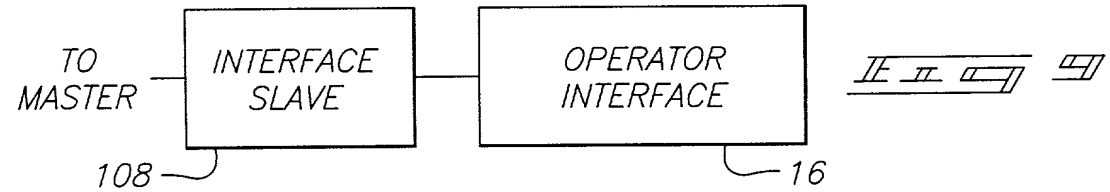

FIG. 9

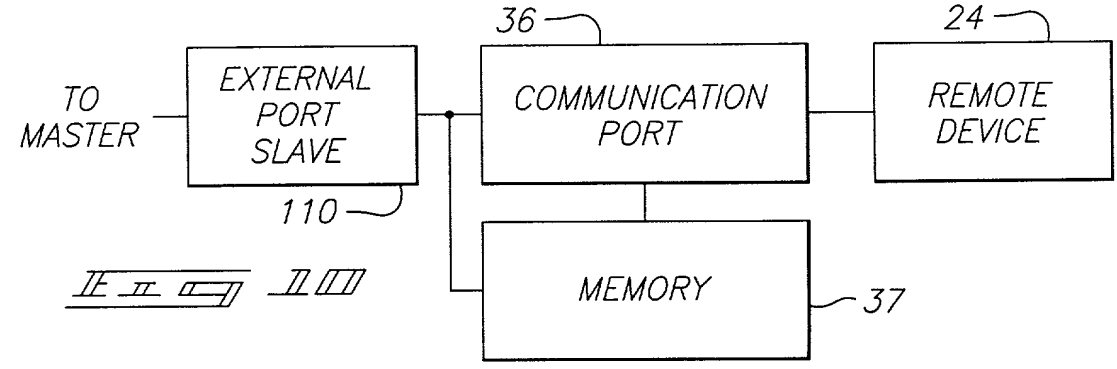

FIG. 10

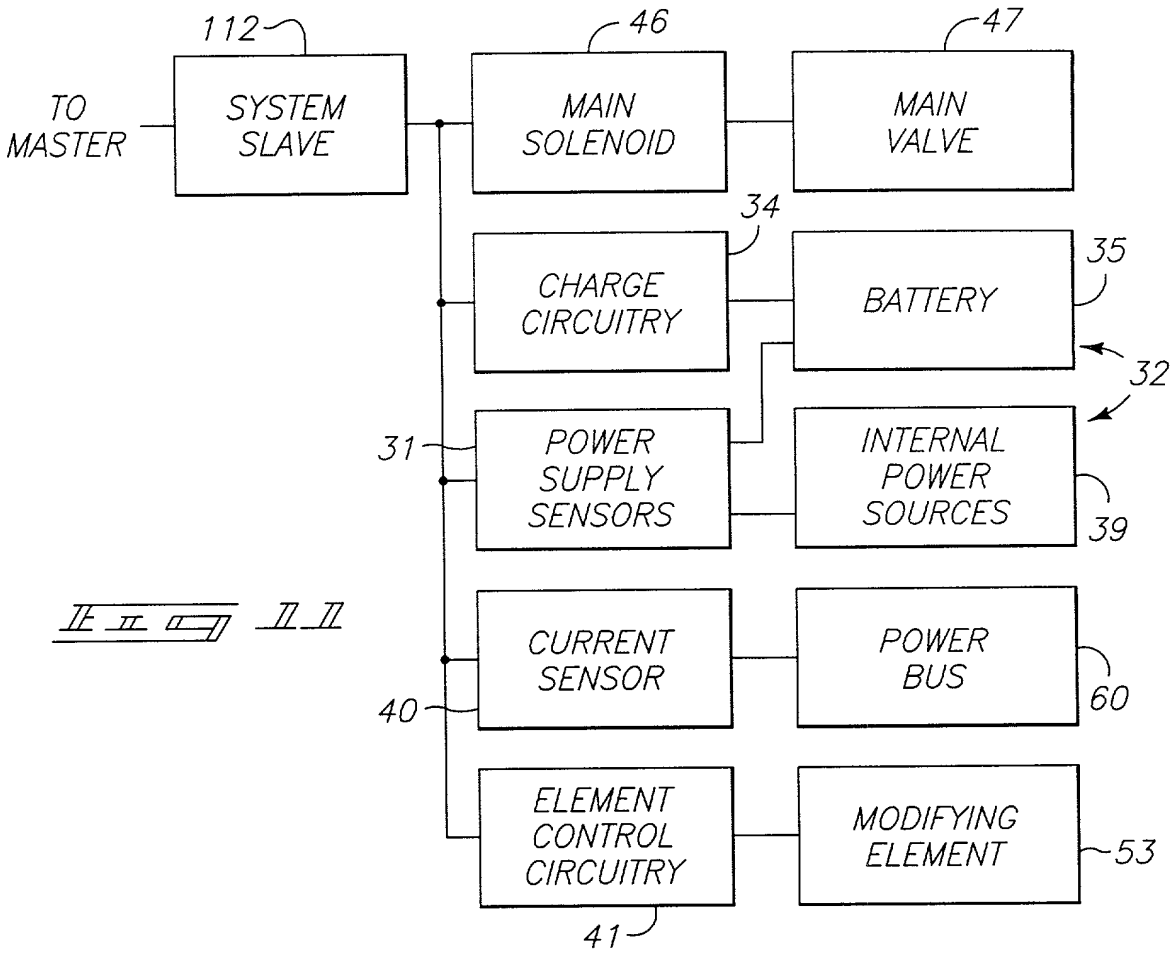
112
TO MASTER
SYSTEM SLAVE
46
MAIN SOLENOID
47
MAIN VALVE
34
CHARGE CIRCUITRY
35
BATTERY
32
31
POWER SUPPLY SENSORS
INTERNAL POWER SOURCES
39
CURRENT SENSOR
POWER BUS
60
40
ELEMENT CONTROL CIRCUITRY
MODIFYING ELEMENT
53
41

Fig. 11

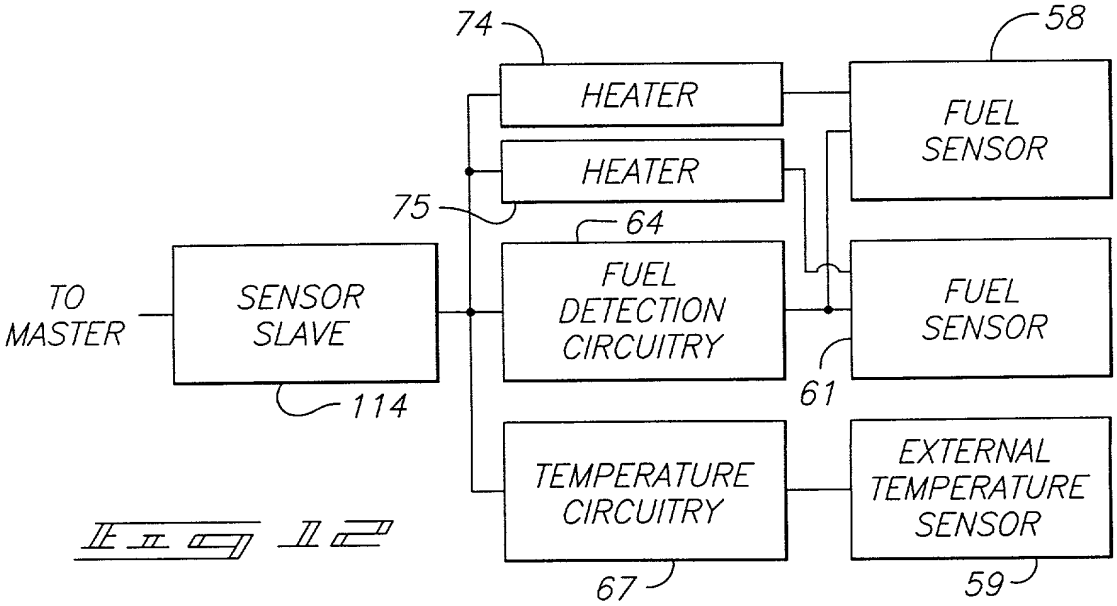
74
58
HEATER
FUEL SENSOR
HEATER
75
64
TO MASTER
SENSOR SLAVE
FUEL DETECTION CIRCUITRY
FUEL SENSOR
61
114
TEMPERATURE CIRCUITRY
EXTERNAL TEMPERATURE SENSOR
67
59

Fig. 12

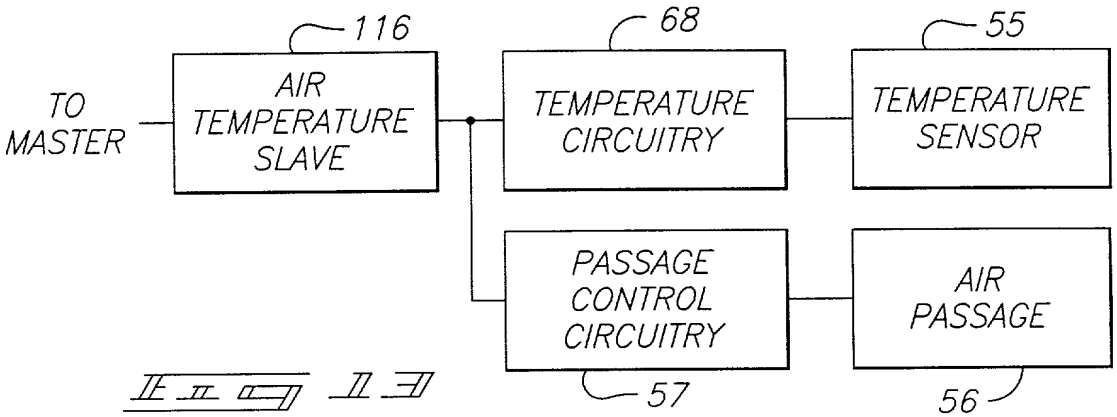

Fig. 13

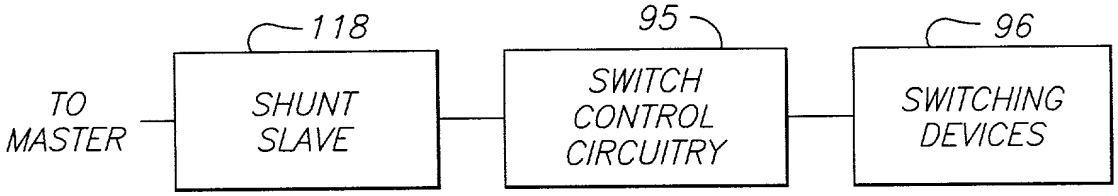

Fig. 14

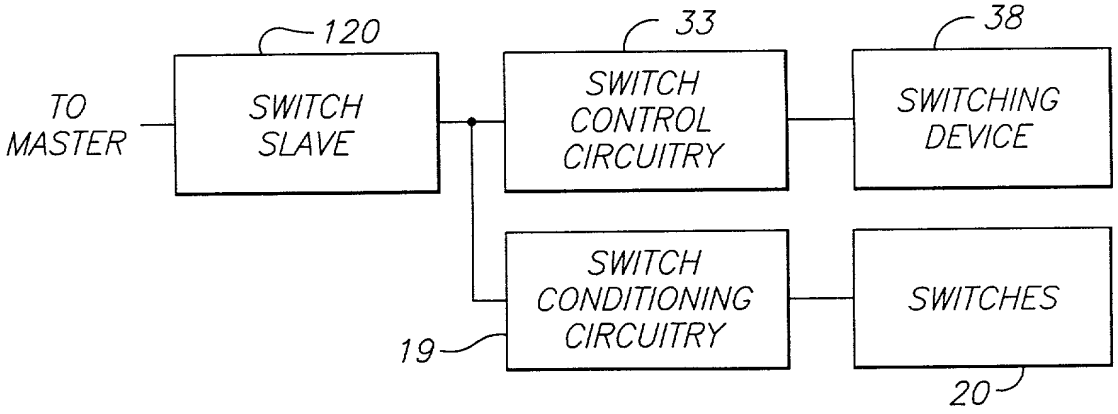

Fig. 15

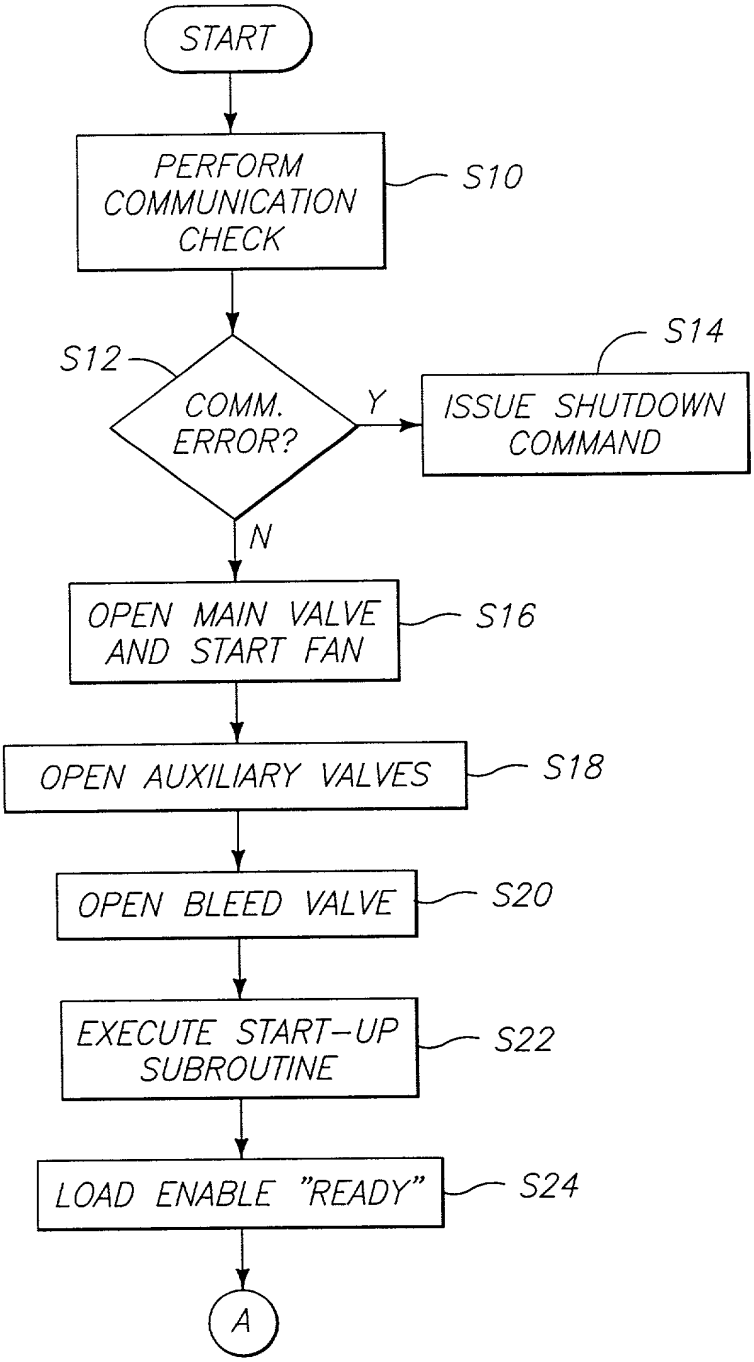
START
PERFORM COMMUNICATION CHECK
S10
S12
COMM. ERROR?
Y
S14
ISSUE SHUTDOWN COMMAND
N
OPEN MAIN VALVE AND START FAN
S16
OPEN AUXILIARY VALVES
S18
OPEN BLEED VALVE
S20
EXECUTE START-UP SUBROUTINE
S22
LOAD ENABLE "READY"
S24
A

Fig 1B

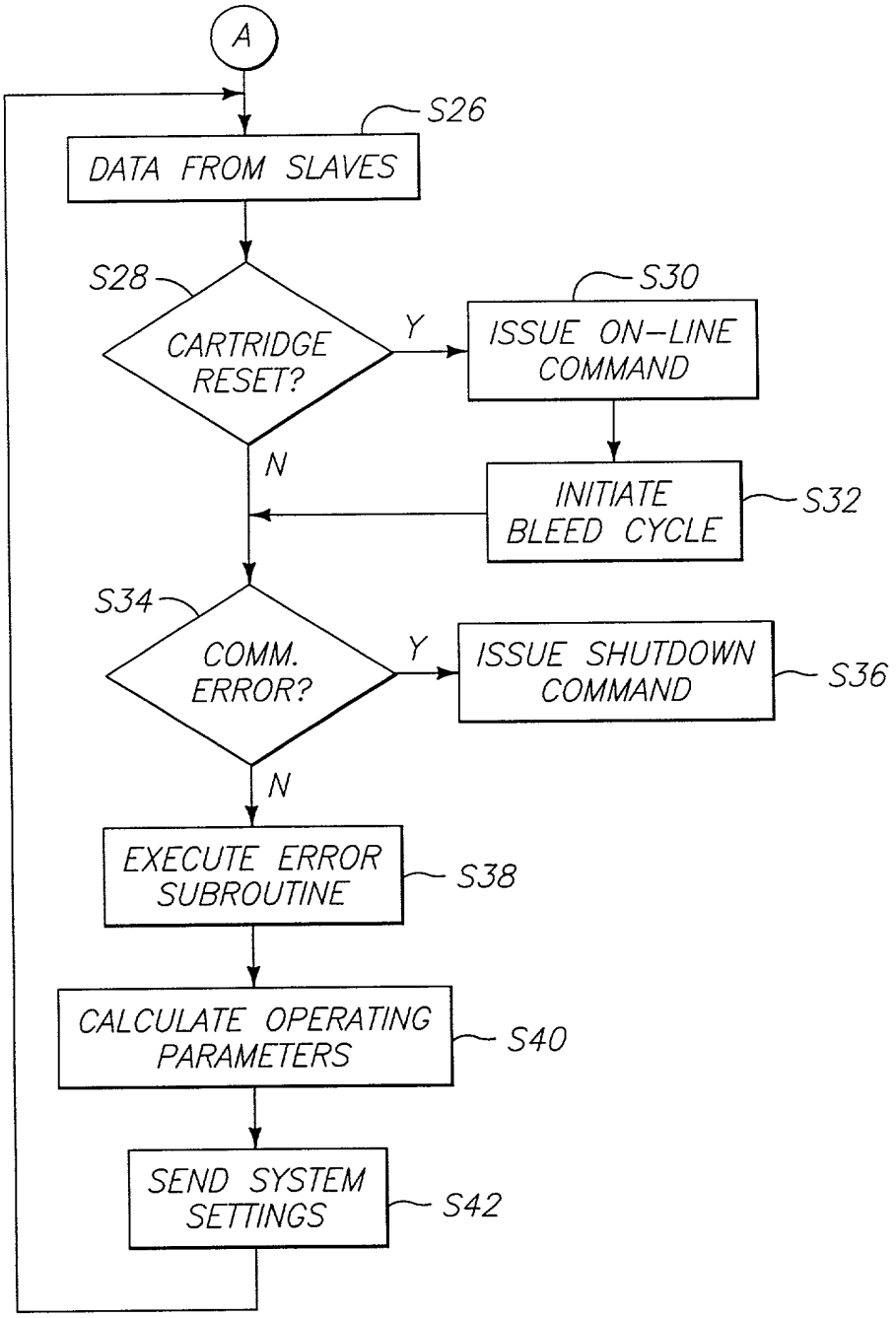
A
S26
DATA FROM SLAVES
S28
CARTRIDGE RESET?
Y
S30
ISSUE ON-LINE COMMAND
N
INITIATE BLEED CYCLE
S32
S34
COMM. ERROR?
Y
ISSUE SHUTDOWN COMMAND
S36
N
EXECUTE ERROR SUBROUTINE
S38
CALCULATE OPERATING PARAMETERS
S40
SEND SYSTEM SETTINGS
S42

Fig 16A

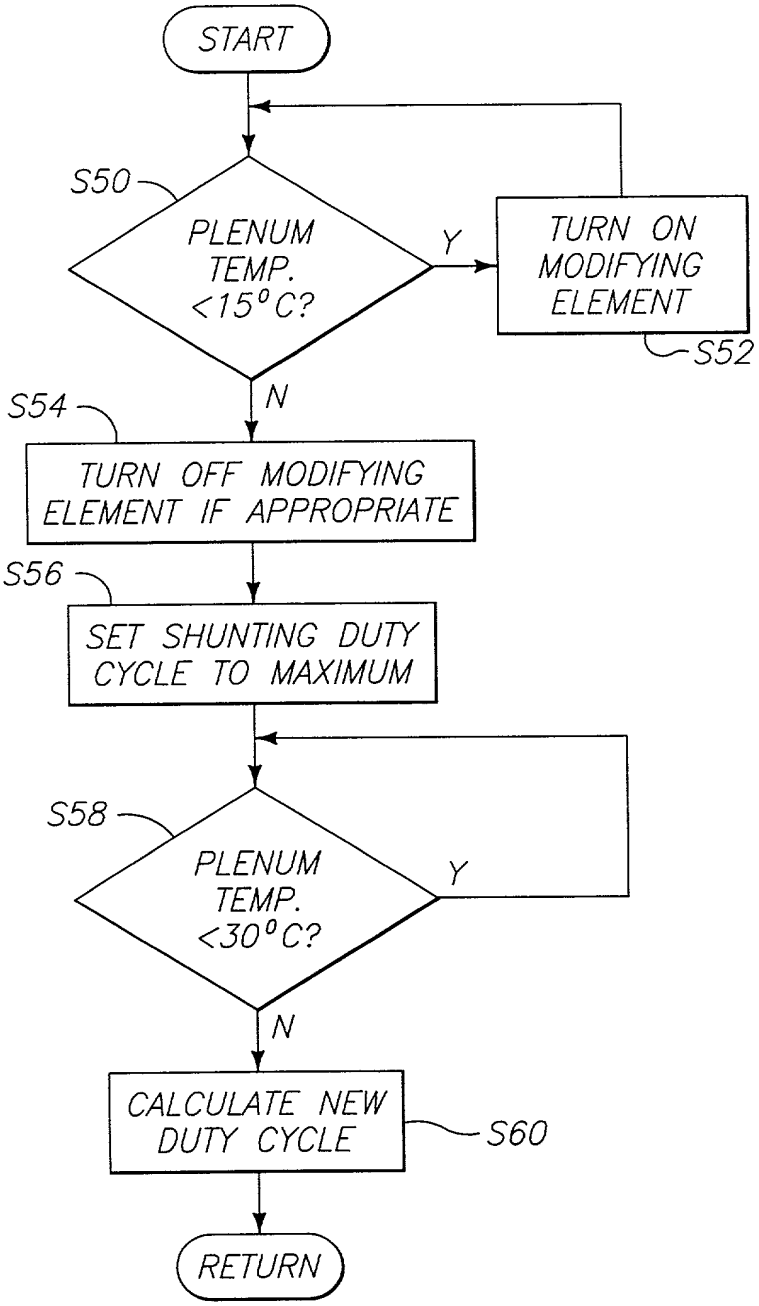
START
S50
PLENUM TEMP. <15°C?
Y
TURN ON MODIFYING ELEMENT
S52
N
S54
TURN OFF MODIFYING ELEMENT IF APPROPRIATE
S56
SET SHUNTING DUTY CYCLE TO MAXIMUM
S58
PLENUM TEMP. <30°C?
Y
N
CALCULATE NEW DUTY CYCLE
S60
RETURN

Fig 11

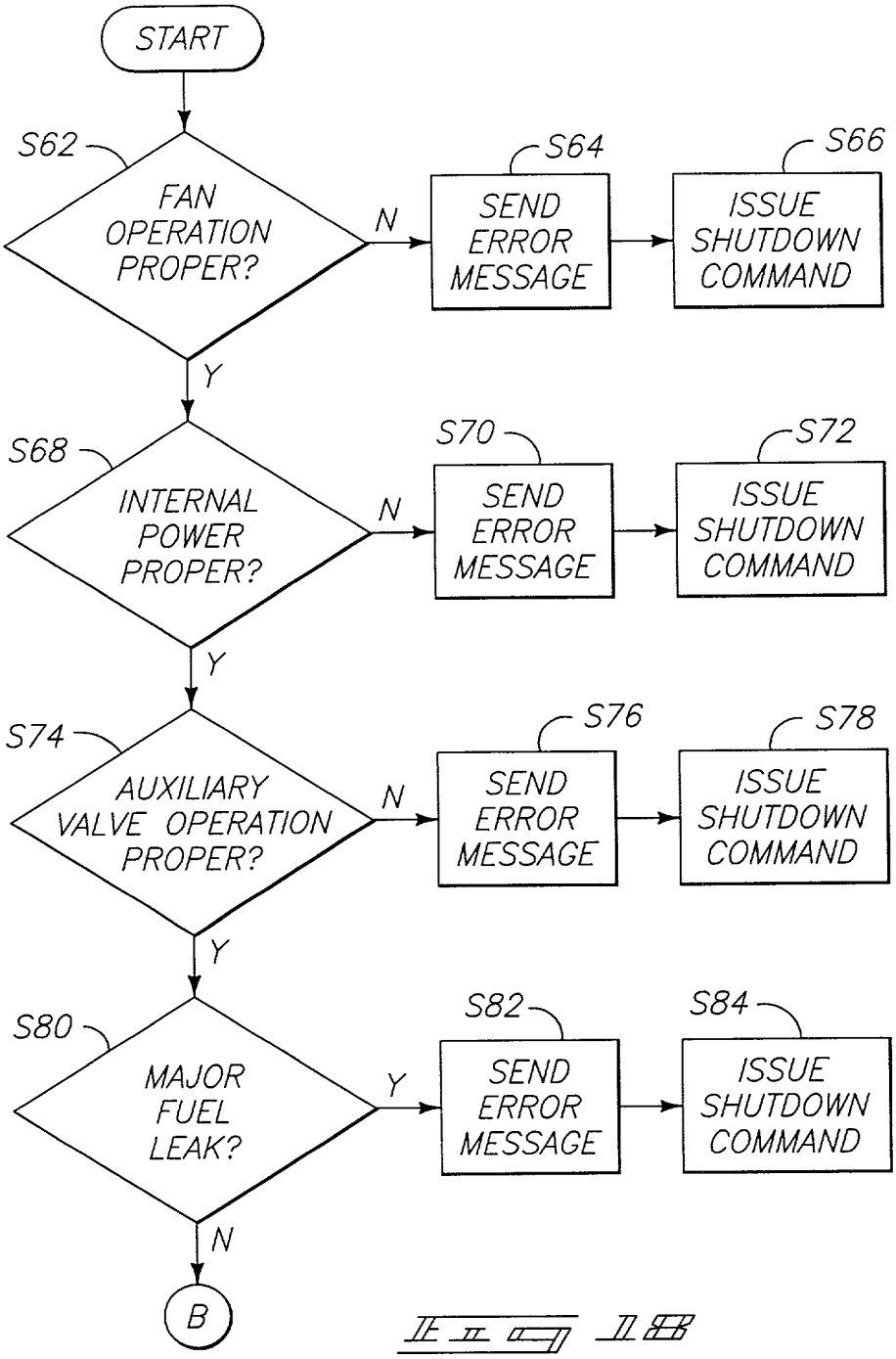
START
S62
FAN OPERATION PROPER?
N
S64
SEND ERROR MESSAGE
S66
ISSUE SHUTDOWN COMMAND
Y
S68
INTERNAL POWER PROPER?
N
S70
SEND ERROR MESSAGE
S72
ISSUE SHUTDOWN COMMAND
Y
S74
AUXILIARY VALVE OPERATION PROPER?
N
S76
SEND ERROR MESSAGE
S78
ISSUE SHUTDOWN COMMAND
Y
S80
MAJOR FUEL LEAK?
Y
S82
SEND ERROR MESSAGE
S84
ISSUE SHUTDOWN COMMAND
N
B

Fig 18

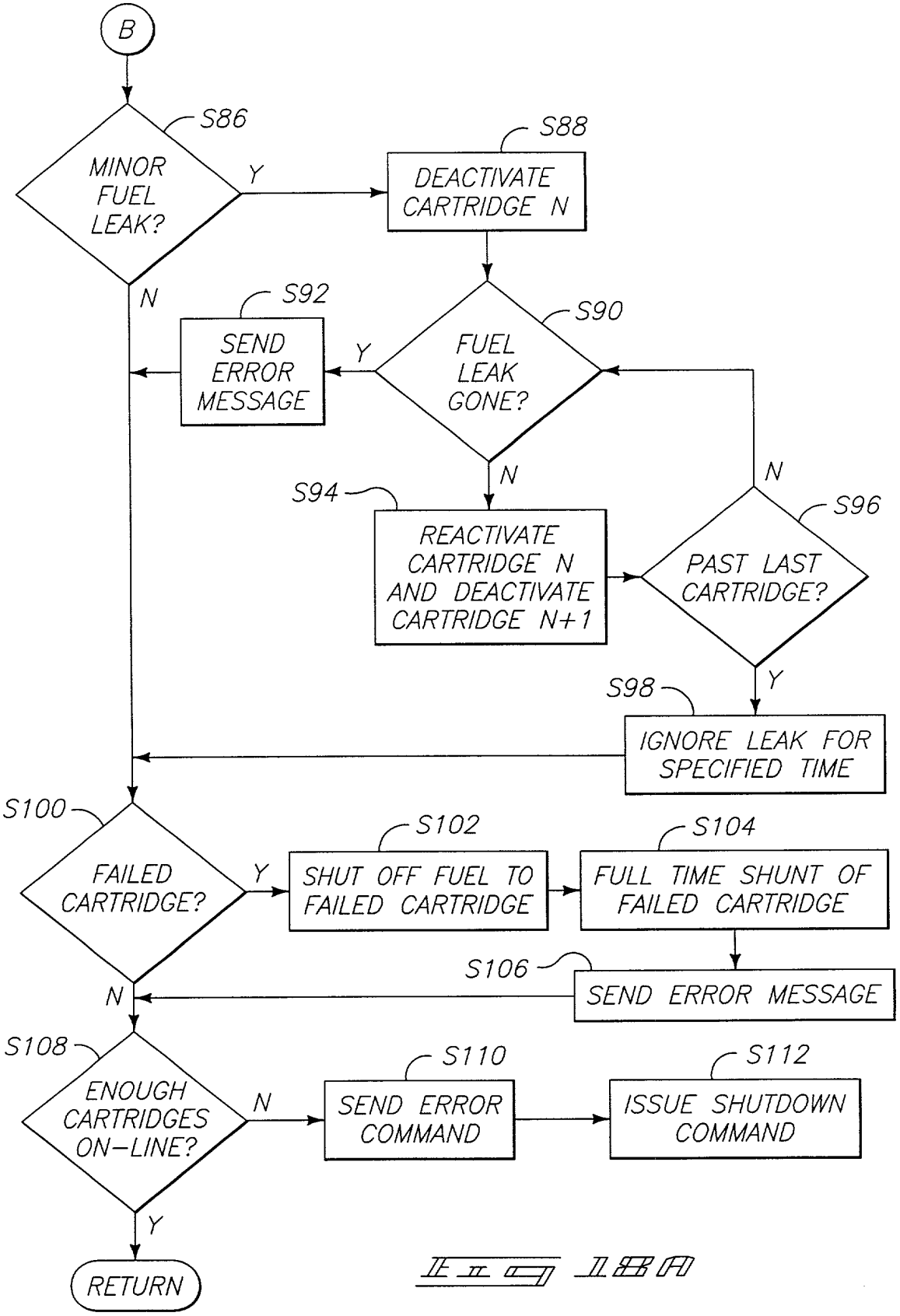
B
S86
MINOR FUEL LEAK?
Y
N
S88
DEACTIVATE CARTRIDGE N
S90
FUEL LEAK GONE?
Y
N
S92
SEND ERROR MESSAGE
S94
REACTIVATE CARTRIDGE N AND DEACTIVATE CARTRIDGE N+1
S96
PAST LAST CARTRIDGE?
N
Y
S98
IGNORE LEAK FOR SPECIFIED TIME
S100
FAILED CARTRIDGE?
Y
N
S102
SHUT OFF FUEL TO FAILED CARTRIDGE
S104
FULL TIME SHUNT OF FAILED CARTRIDGE
S106
SEND ERROR MESSAGE
S108
ENOUGH CARTRIDGES ON-LINE?
N
Y
S110
SEND ERROR COMMAND
S112
ISSUE SHUTDOWN COMMAND
RETURN

Fig 18A

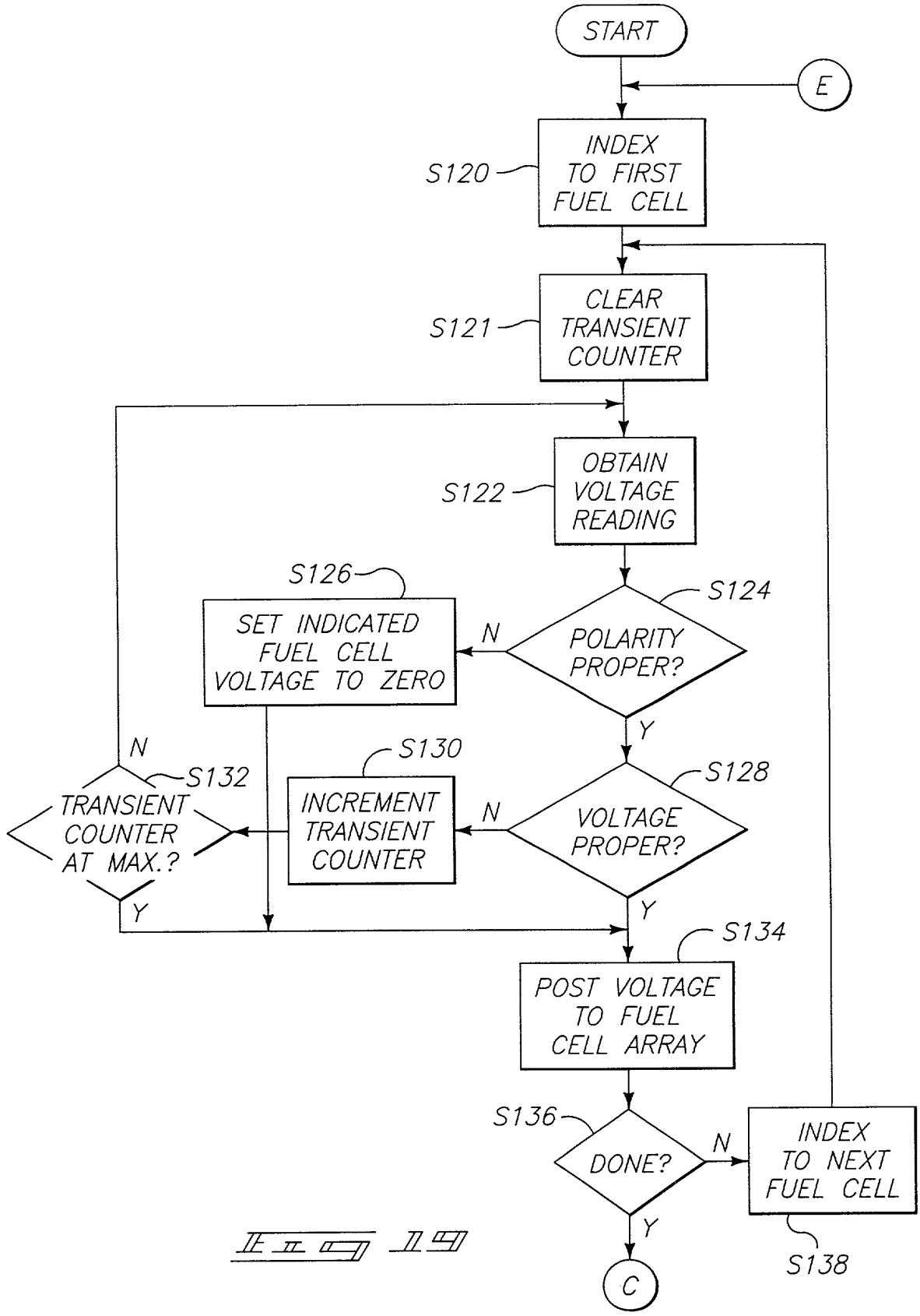
START
E
INDEX TO FIRST FUEL CELL
S120
CLEAR TRANSIENT COUNTER
S121
OBTAIN VOLTAGE READING
S122
POLARITY PROPER?
S124
N
SET INDICATED FUEL CELL VOLTAGE TO ZERO
S126
Y
VOLTAGE PROPER?
S128
N
INCREMENT TRANSIENT COUNTER
S130
Y
TRANSIENT COUNTER AT MAX.?
S132
N
Y
POST VOLTAGE TO FUEL CELL ARRAY
S134
DONE?
S136
N
INDEX TO NEXT FUEL CELL
S138
Y
C

Fig 19

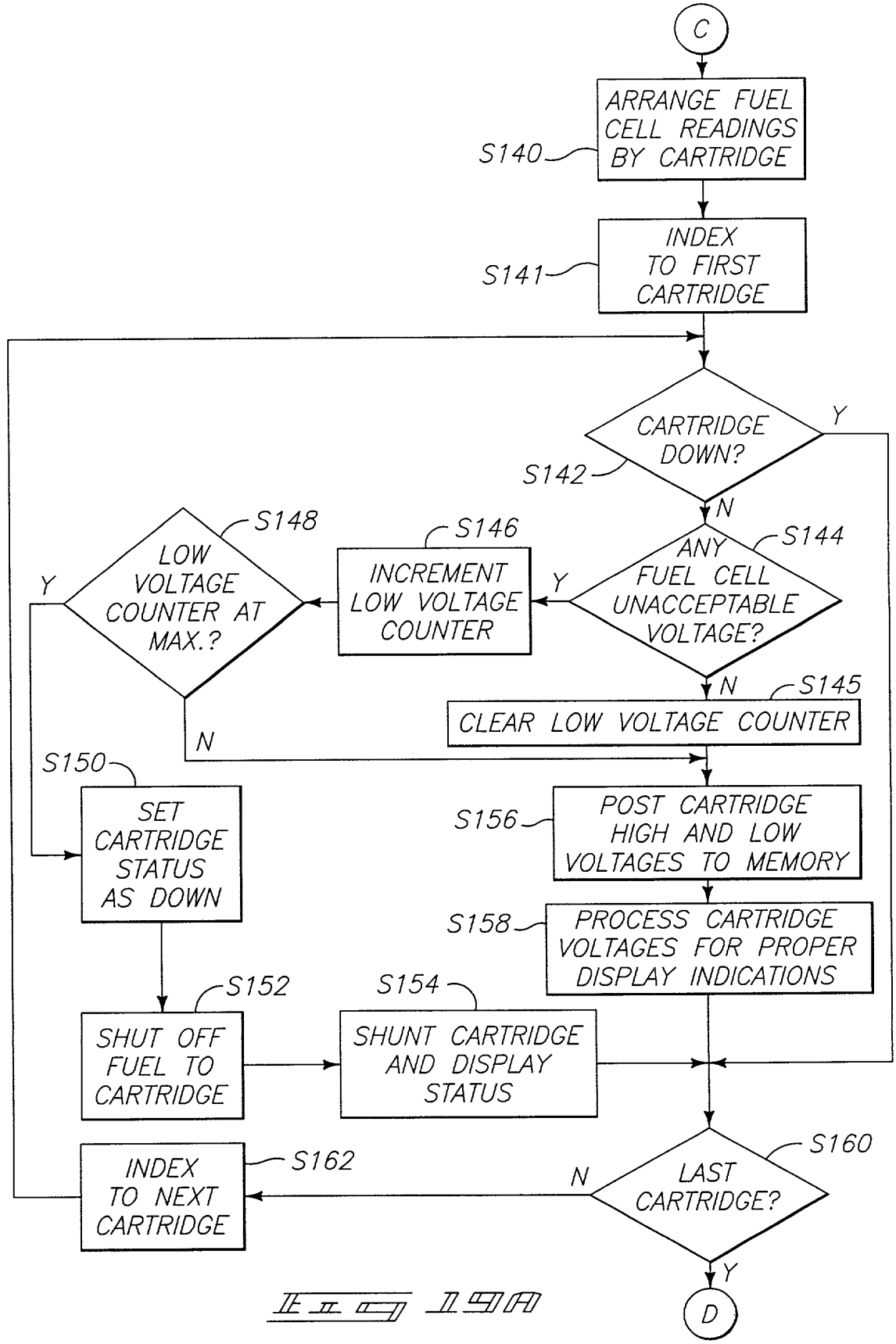
C
ARRANGE FUEL CELL READINGS BY CARTRIDGE
S140
INDEX TO FIRST CARTRIDGE
S141
CARTRIDGE DOWN?
S142
Y
N
ANY FUEL CELL UNACCEPTABLE VOLTAGE?
S144
Y
INCREMENT LOW VOLTAGE COUNTER
S146
Y
LOW VOLTAGE COUNTER AT MAX.?
S148
N
N
CLEAR LOW VOLTAGE COUNTER
S145
SET CARTRIDGE STATUS AS DOWN
S150
POST CARTRIDGE HIGH AND LOW VOLTAGES TO MEMORY
S156
PROCESS CARTRIDGE VOLTAGES FOR PROPER DISPLAY INDICATIONS
S158
SHUT OFF FUEL TO CARTRIDGE
S152
SHUNT CARTRIDGE AND DISPLAY STATUS
S154
LAST CARTRIDGE?
S160
N
INDEX TO NEXT CARTRIDGE
S162
Y
D

Fig 19A

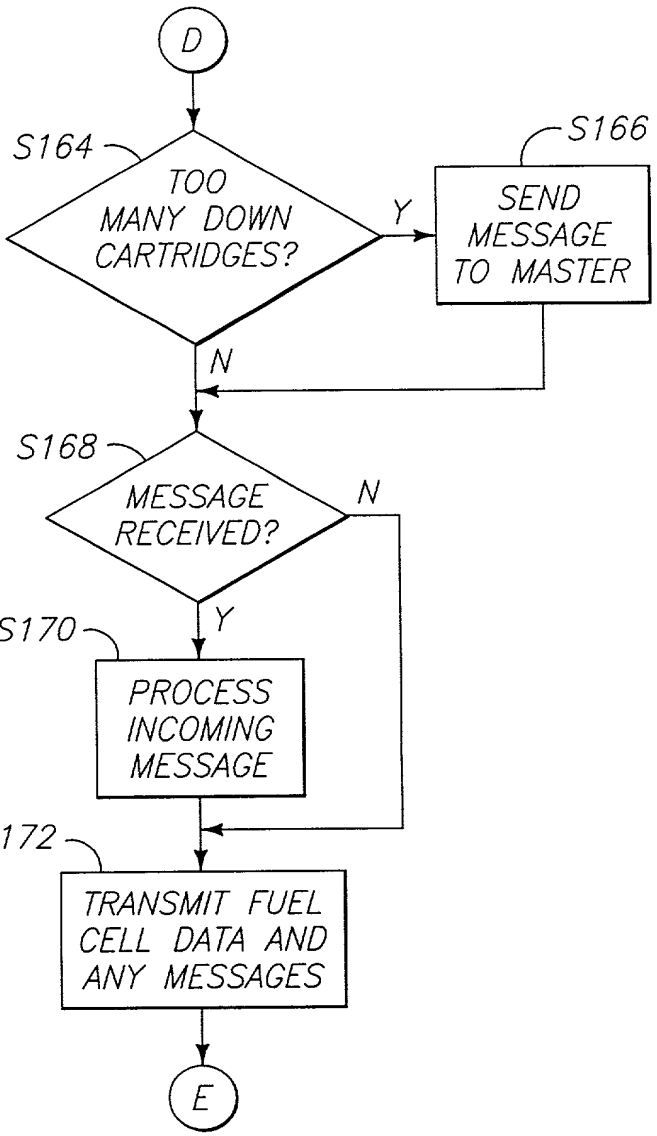
D
S164
TOO MANY DOWN CARTRIDGES?
Y
S166
SEND MESSAGE TO MASTER
N
S168
MESSAGE RECEIVED?
N
Y
S170
PROCESS INCOMING MESSAGE
S172
TRANSMIT FUEL CELL DATA AND ANY MESSAGES
E

Fig 19B

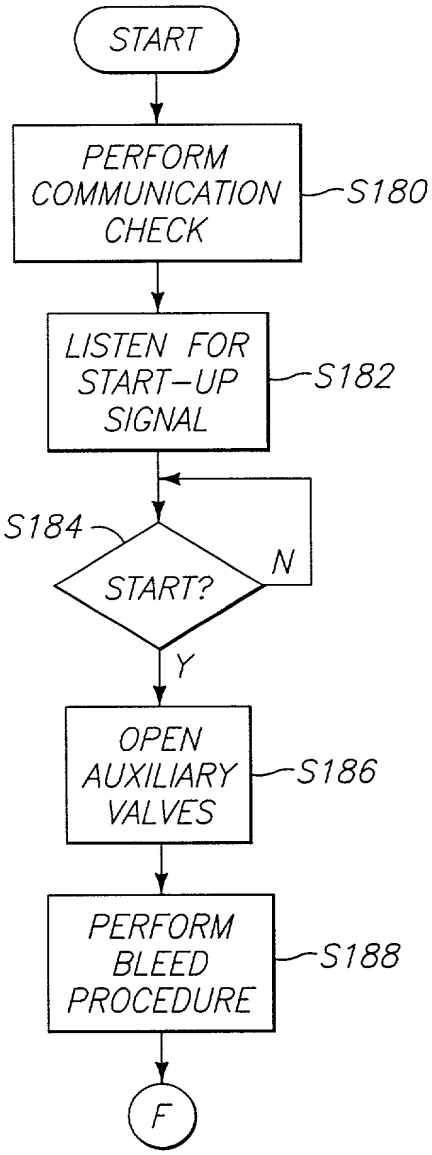
START
PERFORM COMMUNICATION CHECK
S180
LISTEN FOR START-UP SIGNAL
S182
S184
START?
N
Y
OPEN AUXILIARY VALVES
S186
PERFORM BLEED PROCEDURE
S188
F

Fig 20

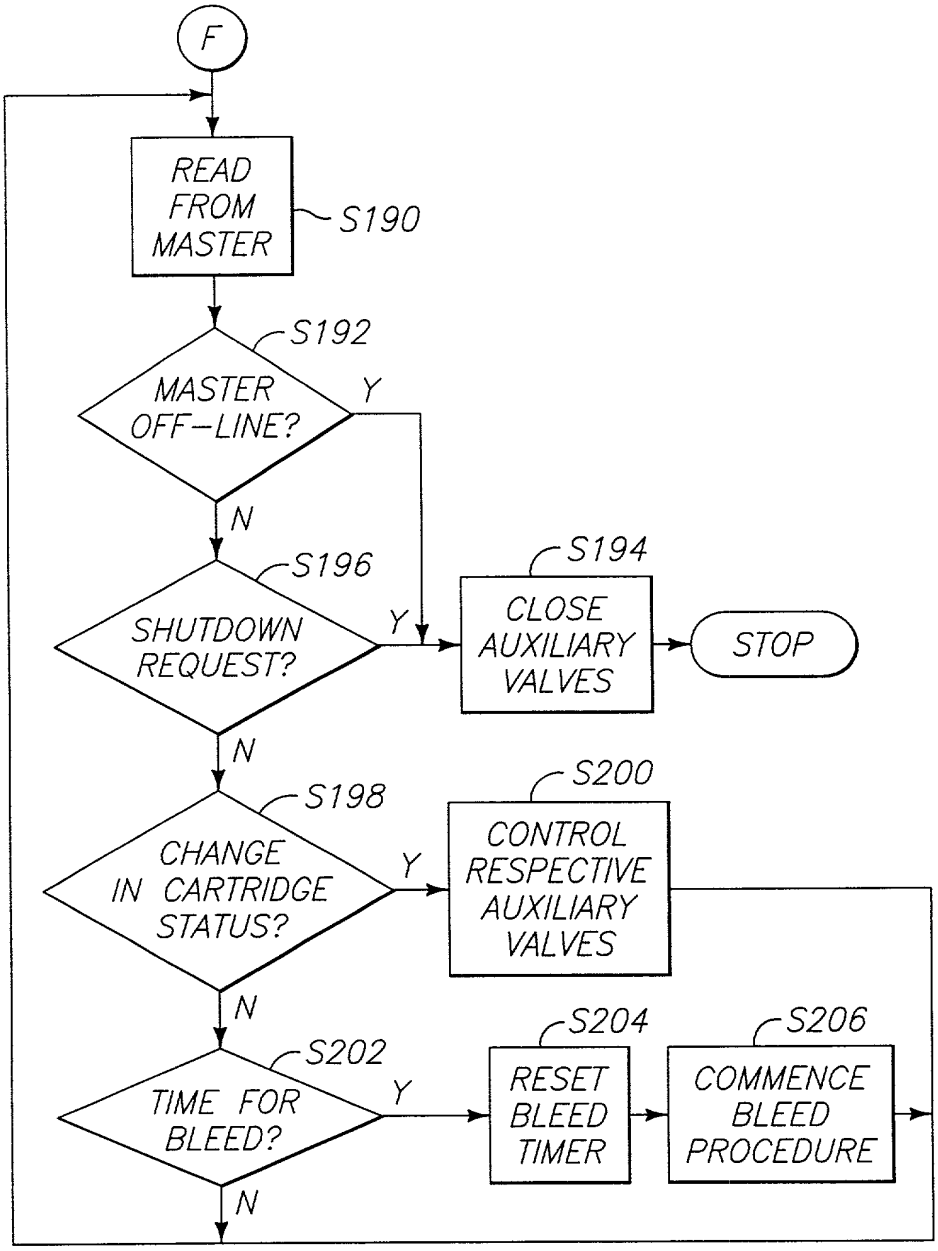
F
READ FROM MASTER
S190
S192
MASTER OFF-LINE?
Y
N
S196
SHUTDOWN REQUEST?
Y
S194
CLOSE AUXILIARY VALVES
STOP
N
S198
CHANGE IN CARTRIDGE STATUS?
Y
S200
CONTROL RESPECTIVE AUXILIARY VALVES
N
S202
TIME FOR BLEED?
Y
S204
RESET BLEED TIMER
S206
COMMENCE BLEED PROCEDURE
N

Fig 20A

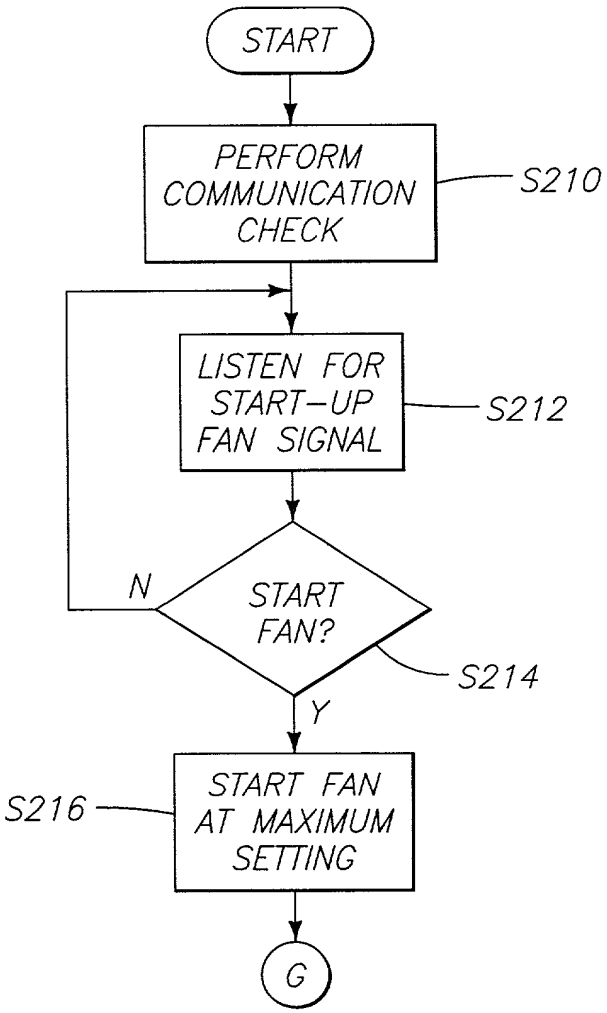
START
PERFORM COMMUNICATION CHECK
S210
LISTEN FOR START-UP FAN SIGNAL
S212
START FAN?
N
S214
Y
START FAN AT MAXIMUM SETTING
S216
G

Fig 2 II

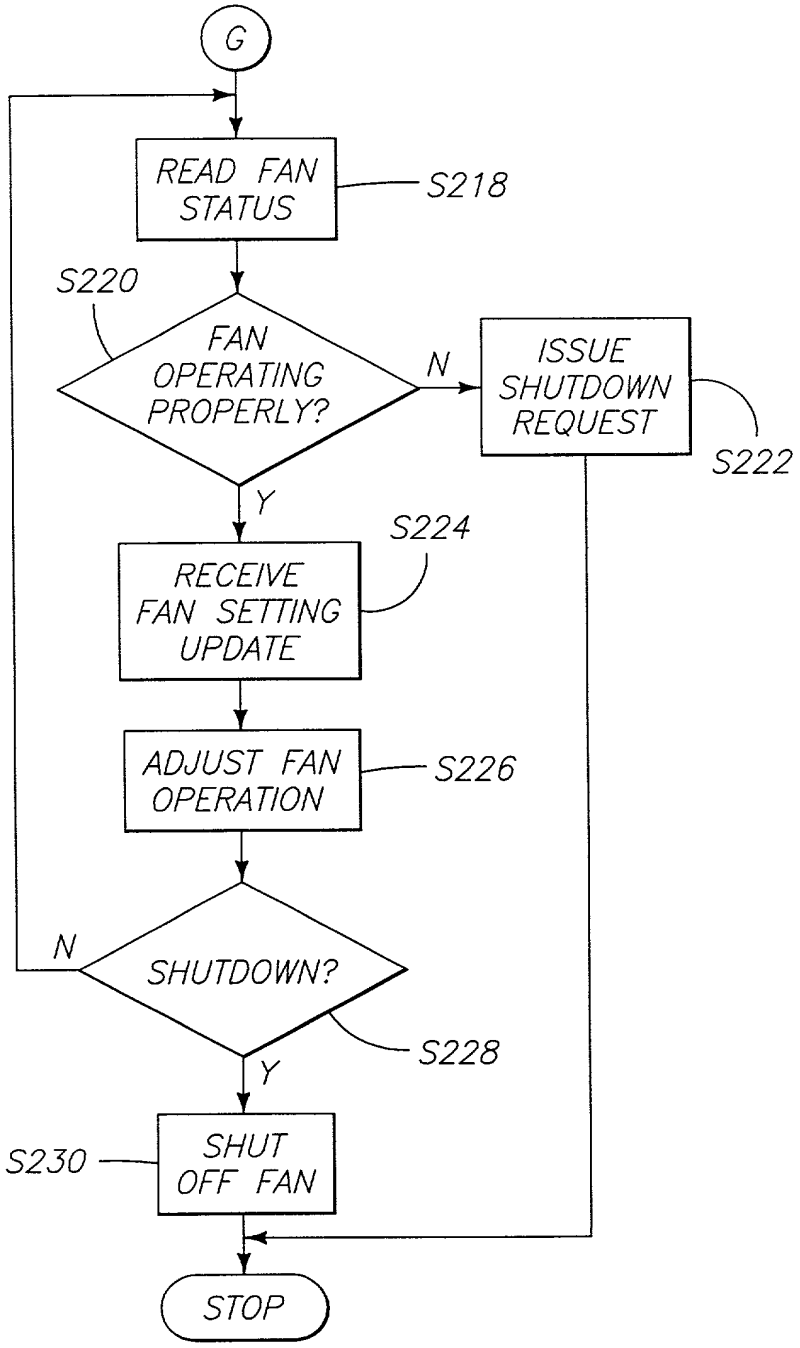
G
READ FAN STATUS
S218
S220
FAN OPERATING PROPERLY?
N
ISSUE SHUTDOWN REQUEST
S222
Y
S224
RECEIVE FAN SETTING UPDATE
ADJUST FAN OPERATION
S226
N
SHUTDOWN?
S228
Y
S230
SHUT OFF FAN
STOP

Fig 21A

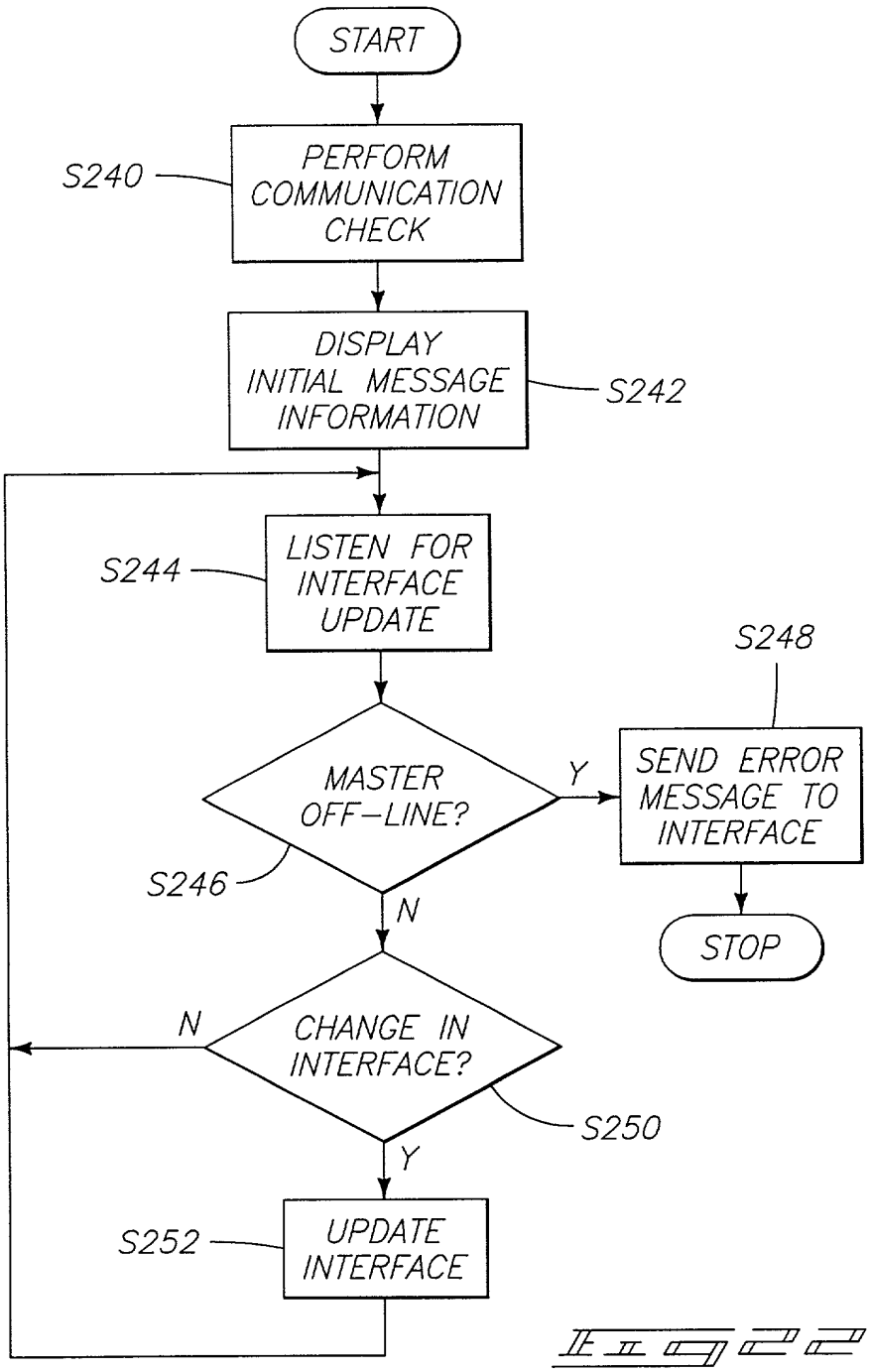
START
S240
PERFORM COMMUNICATION CHECK
DISPLAY INITIAL MESSAGE INFORMATION
S242
S244
LISTEN FOR INTERFACE UPDATE
S248
MASTER OFF-LINE?
Y
SEND ERROR MESSAGE TO INTERFACE
S246
N
STOP
N
CHANGE IN INTERFACE?
S250
Y
S252
UPDATE INTERFACE

Fig 22

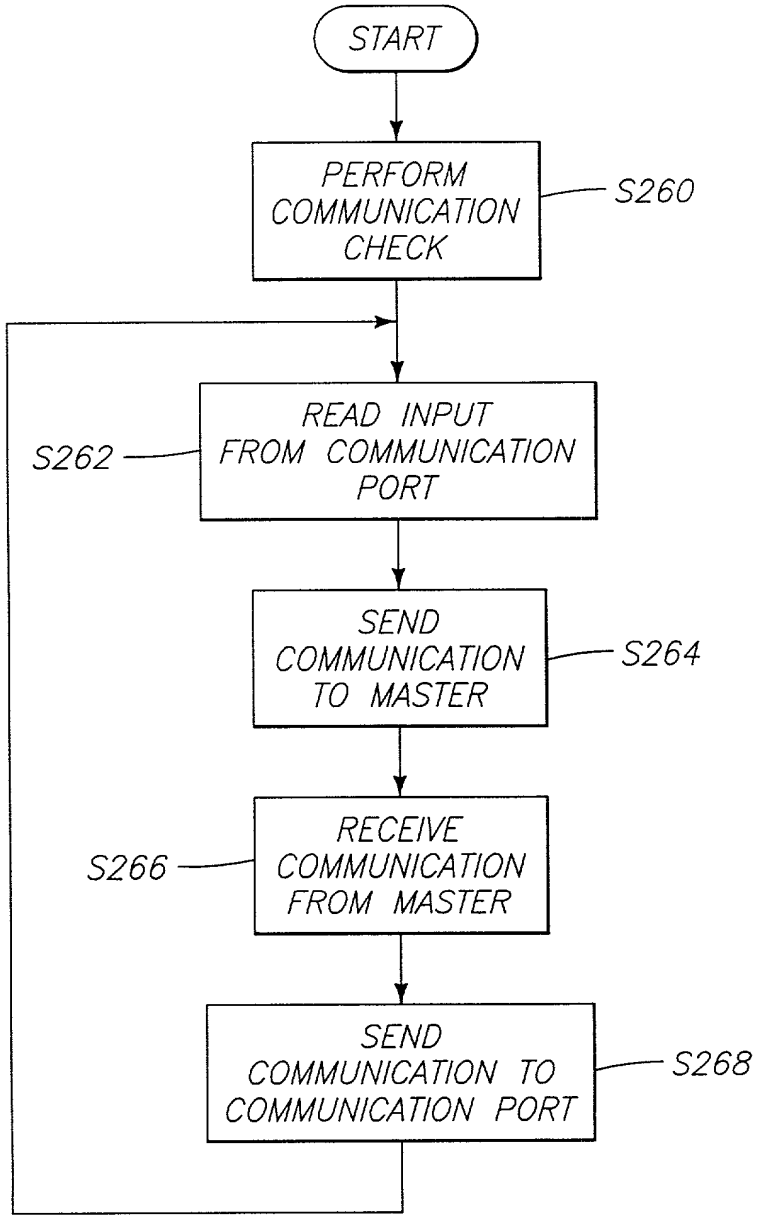
START
PERFORM COMMUNICATION CHECK
S260
READ INPUT FROM COMMUNICATION PORT
S262
SEND COMMUNICATION TO MASTER
S264
RECEIVE COMMUNICATION FROM MASTER
S266
SEND COMMUNICATION TO COMMUNICATION PORT
S268

Fig 23

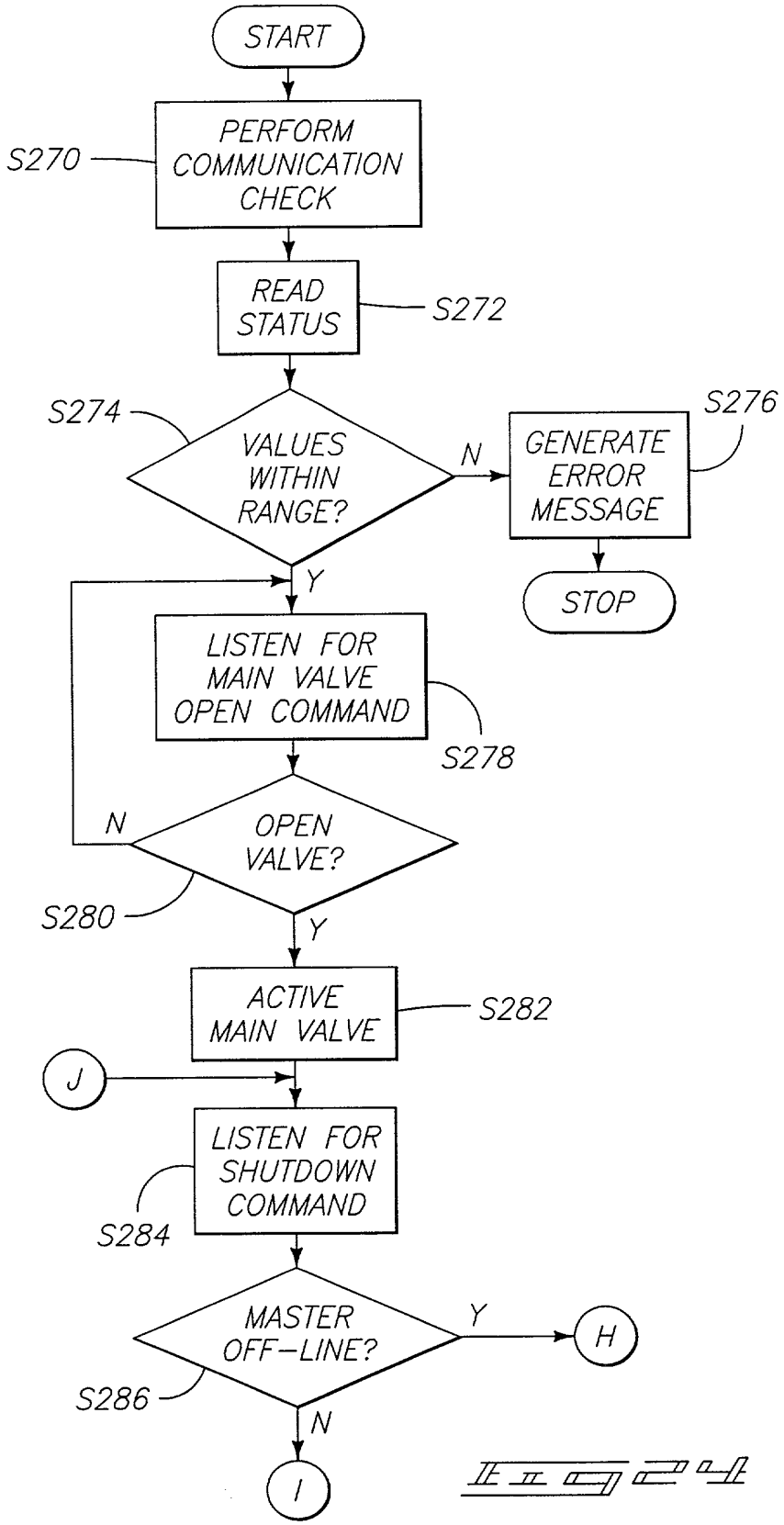
START
PERFORM COMMUNICATION CHECK
S270
READ STATUS
S272
S274
VALUES WITHIN RANGE?
N
GENERATE ERROR MESSAGE
S276
STOP
Y
LISTEN FOR MAIN VALVE OPEN COMMAND
S278
N
OPEN VALVE?
S280
Y
ACTIVE MAIN VALVE
S282
J
LISTEN FOR SHUTDOWN COMMAND
S284
MASTER OFF-LINE?
Y
H
S286
N
I

Fig 24

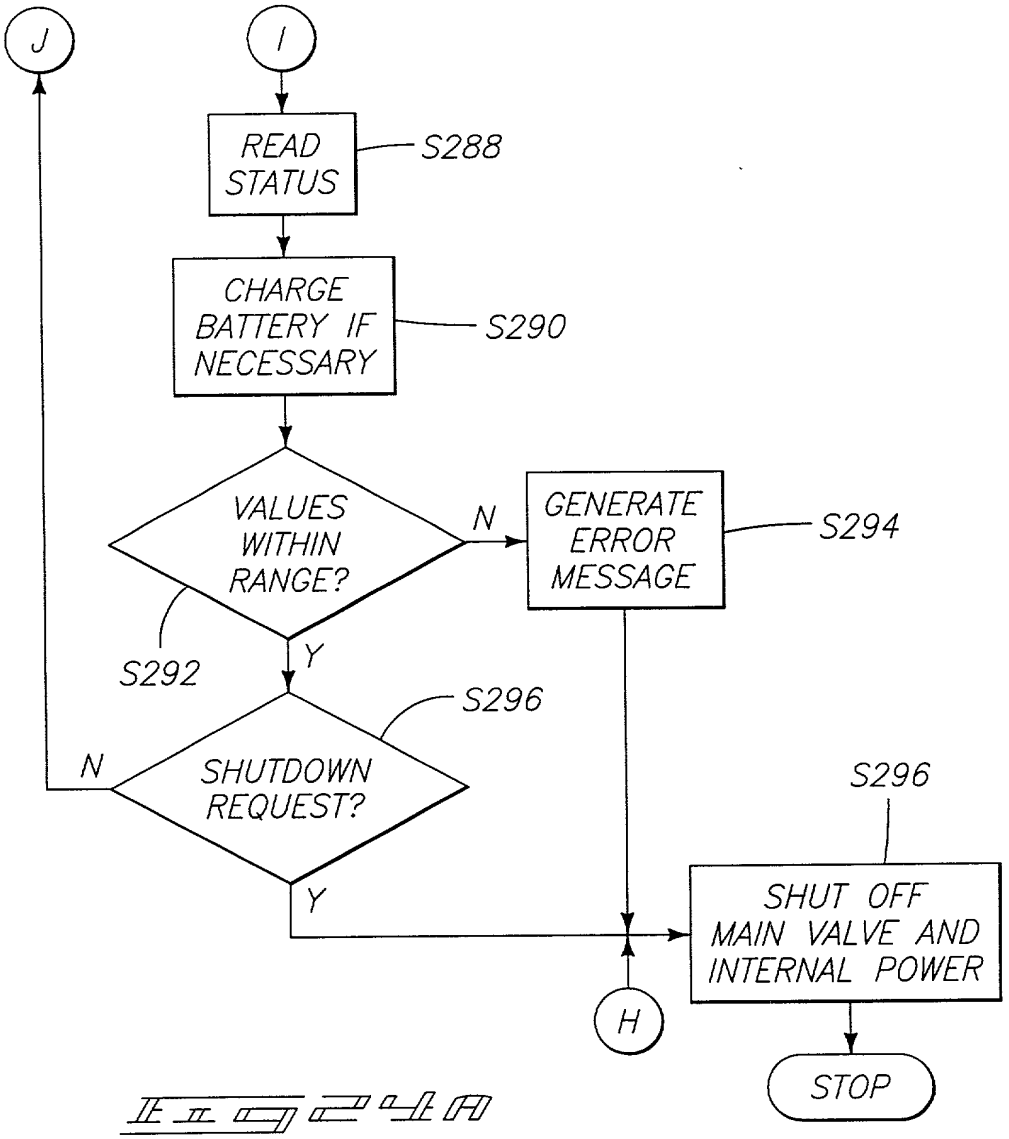
J
I
READ STATUS
S288
CHARGE BATTERY IF NECESSARY
S290
VALUES WITHIN RANGE?
N
GENERATE ERROR MESSAGE
S294
S292
Y
S296
N
SHUTDOWN REQUEST?
S296
Y
SHUT OFF MAIN VALVE AND INTERNAL POWER
H
STOP

Fig 24A

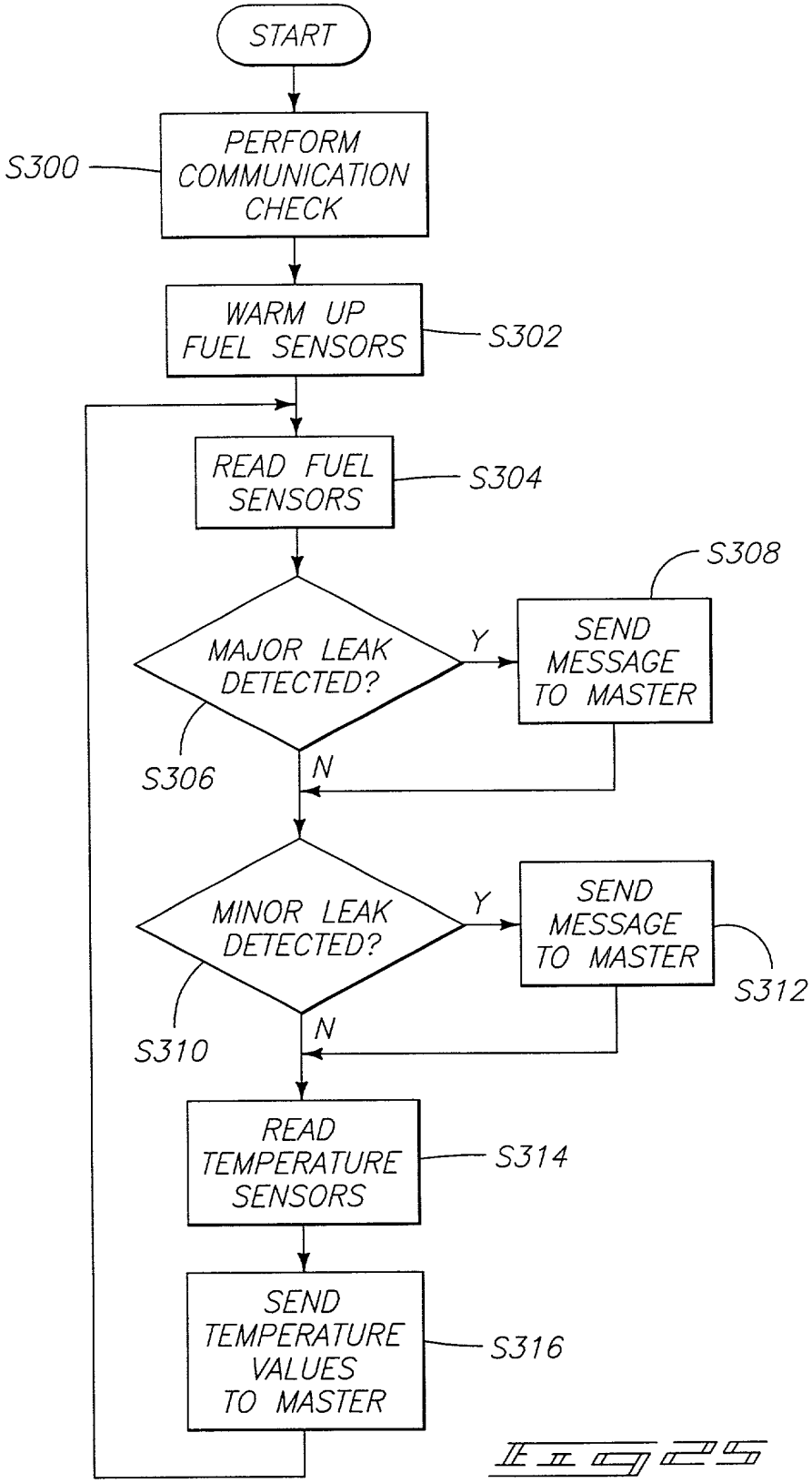
START
PERFORM COMMUNICATION CHECK
S300
WARM UP FUEL SENSORS
S302
READ FUEL SENSORS
S304
MAJOR LEAK DETECTED?
Y
SEND MESSAGE TO MASTER
S308
S306
N
MINOR LEAK DETECTED?
Y
SEND MESSAGE TO MASTER
S312
S310
N
READ TEMPERATURE SENSORS
S314
SEND TEMPERATURE VALUES TO MASTER
S316

Fig 25

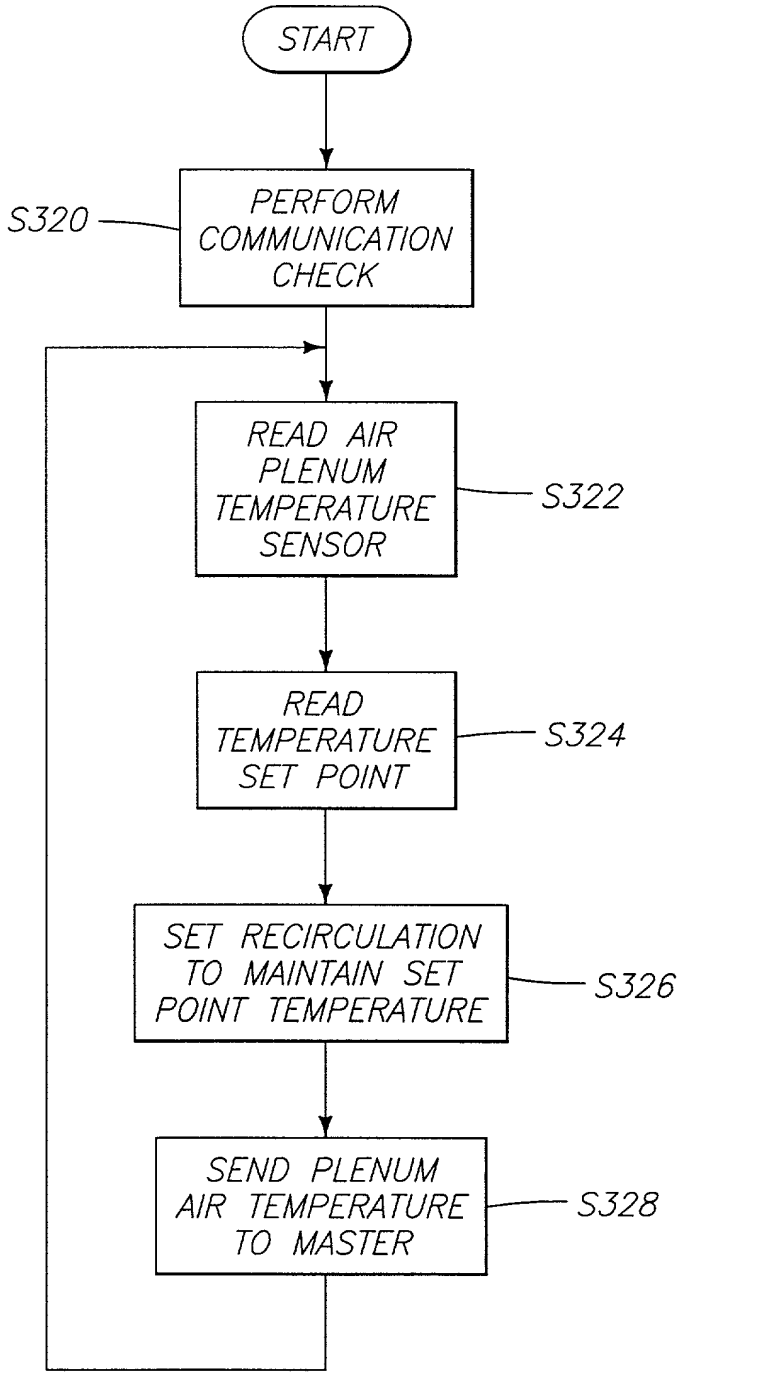
START
S320
PERFORM COMMUNICATION CHECK
READ AIR PLENUM TEMPERATURE SENSOR
S322
READ TEMPERATURE SET POINT
S324
SET RECIRCULATION TO MAINTAIN SET POINT TEMPERATURE
S326
SEND PLENUM AIR TEMPERATURE TO MASTER
S328

Fig 26

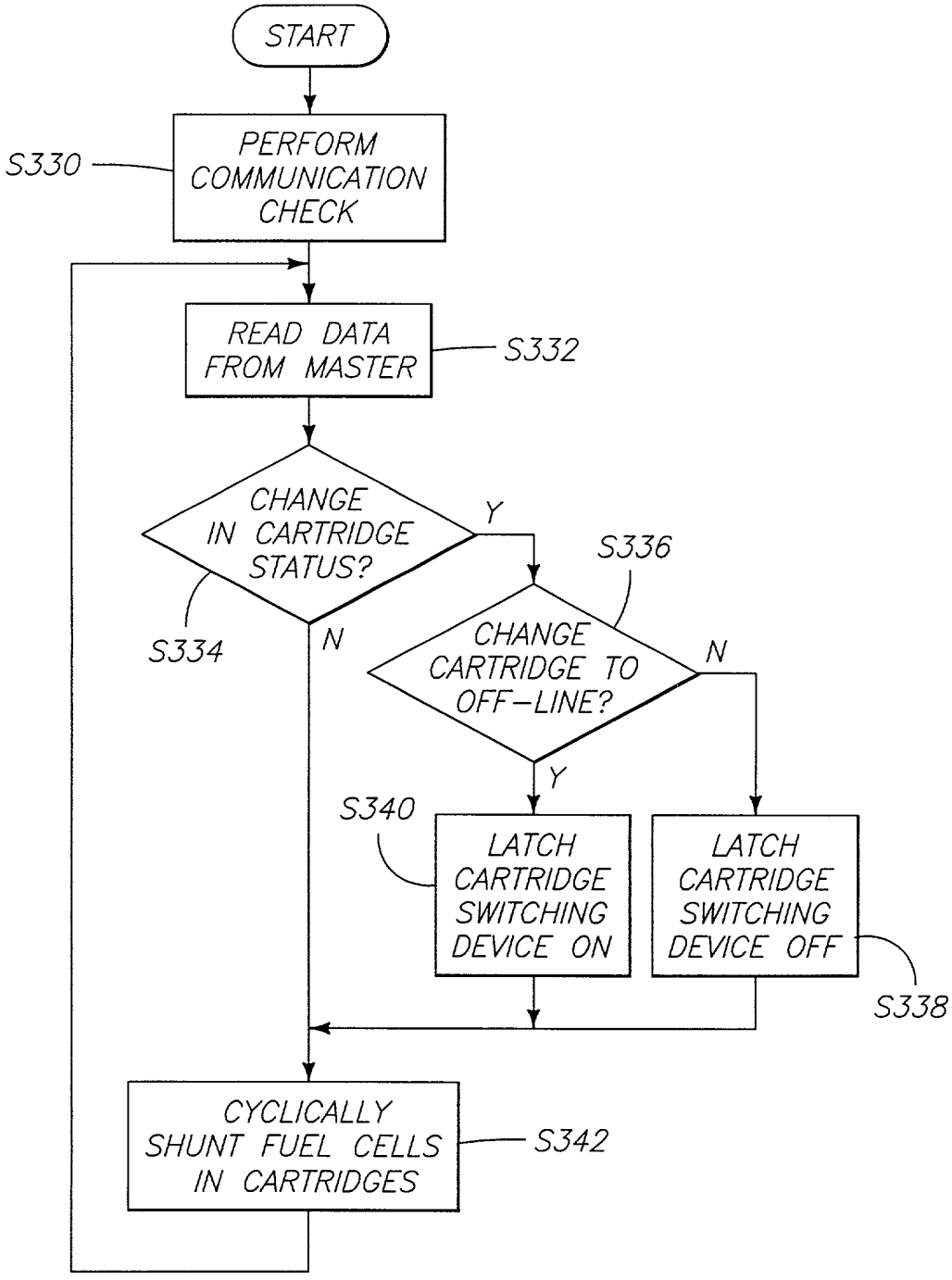
START
PERFORM COMMUNICATION CHECK
S330
READ DATA FROM MASTER
S332
CHANGE IN CARTRIDGE STATUS?
Y
N
S334
S336
CHANGE CARTRIDGE TO OFF-LINE?
N
Y
S340
LATCH CARTRIDGE SWITCHING DEVICE ON
LATCH CARTRIDGE SWITCHING DEVICE OFF
S338
CYCLICALLY SHUNT FUEL CELLS IN CARTRIDGES
S342

Fig 27

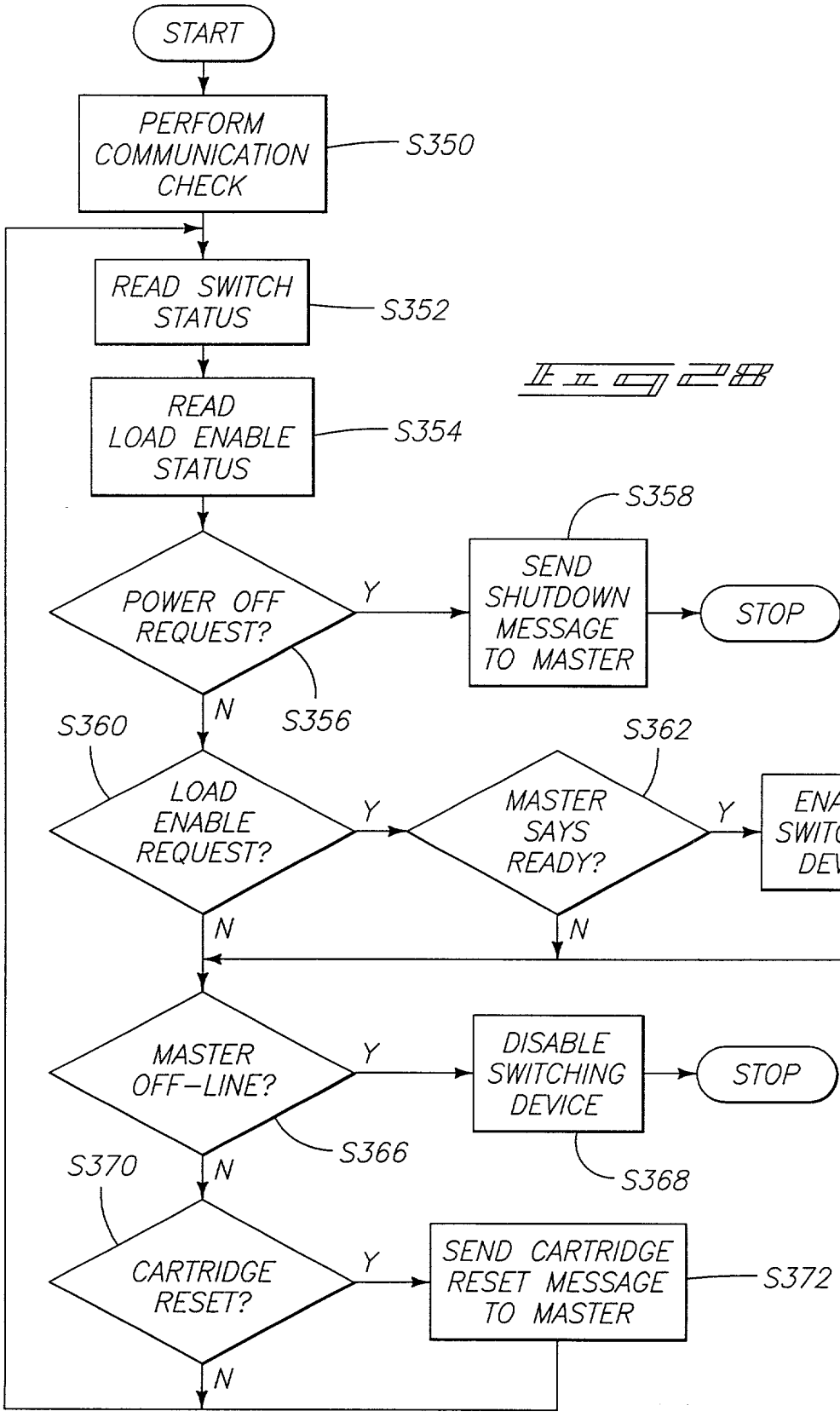
START
PERFORM COMMUNICATION CHECK
S350
READ SWITCH STATUS
S352
READ LOAD ENABLE STATUS
S354
POWER OFF REQUEST?
Y
S358
SEND SHUTDOWN MESSAGE TO MASTER
STOP
N
S356
S360
LOAD ENABLE REQUEST?
Y
S362
MASTER SAYS READY?
Y
S364
ENABLE SWITCHING DEVICE
N
N
MASTER OFF-LINE?
Y
DISABLE SWITCHING DEVICE
STOP
S366
S368
S370
N
CARTRIDGE RESET?
Y
SEND CARTRIDGE RESET MESSAGE TO MASTER
S372
N

Fig 28